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Systematic Revision of the Catfish Genus *Silurus*, with Description of a New Species from Thailand and Burma

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Abstract On the basis of external morphology and anatomy, 17 scpeies of the genus *Silurus* Linnaeus including a new species, *S. torrentis* from Thailand and Burma, are recognized as valid. *S. bedfordi* Regan is synonymized with *S. asotus*, and *S. goae* Haig is transferred to the genus *Ompok*. From an anatomical study of 12 species, the diagnostic feature of the genus *Parasilurus* Bleeker is revealed to be invalid, and the genus is synonymized with *Silurus*. From the phylogenetic analysis, the genus *Silurus* is divided into two major species groups, the *cochinchinensis* group which is distributed mainly in Southeast Asia, and the *glanis* group which is further separated into three subgroups occurring separately in East Asia and Europe. The pattern of distribution and relationships between ontogeny and phylogeny in the genus *Silurus* are briefly discussed.

The catfishes of the genera *Silurus* Linnaeus and *Parasilurus* Bleeker are distributed throughout Eurasia except for its central regions (Nikolsky, 1961). Many authors have recognized these two genera solely on the basis of a difference in a single character: *Silurus* having two pairs of mandibular barbels while *Parasilurus* having only a pair (Bleeker, 1862; Nichols, 1943; Berg, 1949; Nikolsky, 1961; Tomoda, 1961). Haig (1950) and Chen (1977), however, claimed that the number of mandibular barbels was not a valid criterion for differentiating these two genera, since intraspecific variation in this character was found within some species.

Although the genus *Silurus*, including *Parasilurus*, has been reviewed by Haig (1950), her study was made only as part of a revision of the family Siluridae as a whole, and, except for one regional work (Chen, 1977), no detailed revisional work on this genus has ever been conducted during the past thirty years. Consequently, the actual number of species assigned to this genus is currently unclear and the systematic relationships among species of the genus *Silurus* are still quite poorly understood. This is partly due to the difficulty in obtaining several rare species, and partly because no attempt has ever been made to apply advanced taxonomic techniques such as Hennigian phylogenetic analysis (Hennig, 1966; Wiley, 1981) to this group.

In this study I review the species of *Silurus* and *Parasilurus* on the basis of external and anatomical characteristics, examine the taxonomic validity of the latter genus, and then discuss phylogenetic relationships among the species and the zoogeography of the genus *Silurus*.

Materials and methods

Specimens of the following 19 nominal species were examined: *Silurus afghana*, *S. aristotelis*, *S. asotus*, *S. bedfordi*, *S. biwaensis*, *S. cochinchinensis*, *S. gilberti*, *S. glanis*, *S. goae*, *S. grahami*, *S. lanzhouensis*, *S. lithophilus*, *S. mento*, *S. meridionalis*, *S. microdorsalis*, *S. soldatovi*, *S. torrentis* sp. nov., *S. triostegus*, and *S. wynaadensis*. Dissections were made of all these species except *S. afghana*, *S. bedfordi*, *S. lanzhouensis*, *S. soldatovi*, *S. triostegus*, and *S. wynaadensis*. *S. lanzhouensis* and *S. soldatovi* were skinned in the head region to examine the shape of the skull.

For meristic data, including counts of vertebrae, caudal, anal and dorsal fin rays, maximum use of radiograph material was made. The last two rays of the pectoral fin were considered as one. In the anal fin, all the rays that possessed a pterygiophore were counted. In the pelvic and dorsal fins, all the rays were counted, while in the caudal fin only branched rays were counted. The vomerine tooth band was observed either by casting in parafilm sheet, or through radiographs. The measurements were taken after Masuda et al. (1984). Standard length (SL) was measured to the nearest 1 mm with a divider and scale. Measurements less than

100 mm were made to the nearest 0.1 mm. All the measurements less than 10 mm were made under a binocular microscope wtih an ocular micrometer.

The locality names in China follow Ditu Chubanshe (1977). In cases where the exact localities of sites could not be determined on the map, the original records attached to the specimens were described. The materials examined are deposited in the following institutions: British Museum of Natural History (BMNH); California Academy of Sciences (CAS, and SU); Laboratory of Fisheries Biology, Kyushu University (FBKU); Institute of Hydrobiology, Academia Sinica (IHAS); Kunming Institute of Zoology (KIZ); Muséum National d'Histoire Naturelle (MNHN); Swedish Museum of Natural History (NHRM); National Inland Fisheries Institute, Thailand (NIFI); National Science Museum, Tokyo (NSMT); Department of Zoology, University Museum, University of Tokyo (ZUMT).

Materials examined. *S. afghana*: BMNH 1860.3.19: 755, Afghanistan, 110 mm SL, holotype. *S. aristotelis*: NSMT-P 50248–50249, 2 specimens, Lake Greece Occidental, 195 mm and 227 mm SL. *S. asotus*: FBKU, uncatalogued, 9 specimens, Lake Biwa, Japan, 176–458 mm SL; ZUMT 55085–55087, 3 specimens, China, 134–253 mm SL; ZUMT 55088–55101, 14 specimens, Taedong River, Pyongyang, North Korea, 154–224 mm SL; ZUMT 2511, 1 specimen, Tanshui River, Taiwan, 203 mm SL; ZUMT 12887, 1 specimen, Korea, 194 mm SL; ZUMT 48561, 48562, 2 specimens, 188 mm and 406 mm SL; NHRM JGA/1920. 026. 3011, 2 specimens, Tang Hu Fish Market, Jiangning Xian, Jiangxi, China, 244 mm and 246 mm SL; NHRM JGA/1919. 515. 4011, 3 specimens, Chang Jiang, Nanjing, Jiangxi, China, 144–196 mm SL; NHRM JGA/1921. 143. 3012, 4 specimens, Hsin-Chino, Changting Xian, Fujian, China, 120–191 mm SL. *S. bedfordi*: BMNH 1907. 12. 10: 66, Korea, 250 mm SL, holotype (radiograph). *S. biwaensis*: FBKU, uncatalogued, 14 specimens, Lake Biwa, Japan, 165–778 mm SL. *S. cochinchinensis*: MNHN B. 602, Cochinchina, 93.3 mm SL, holotype; BMNH 1938. 12. 1: 135–136, 2 specimens, near Ting-wu, Guangdong, China, 99.6 mm and 115 mm SL; IHAS 1320096, 7 specimens, Hainan, Guangdong, China, 89.1–192 mm SL; FBKU, uncatalogued, 7 specimens, Shantou, Guangdong, China, 60.3–156 mm SL; *S. gilberti*: IHAS 13200103, 7 specimens, Changjing, Hainan, Guangdong, China, 94.3–123 mm SL. *S. glanis*: FBKU, uncatalogued, Danube River, West Germany, 956 mm SL; NSMT-P 50243, 1 specimen (skull), Danube River, Srino, Rumania, 133 mm HL; NSMT-P 50244, locality unknown, 277 mm SL; SU 20587, radiograph, 2 specimens, Volga River, Russia, 248 mm and 254 mm SL; CAS 23338, radiograph, 2 specimens, Danube River, near Braila, Rumania, 269 mm and 287 mm SL. *S. goae*: SU 41889, Goa, India, 234 mm SL, holotype; CAS 60707, 1 specimen, Karnataka, India, 223 mm SL. *S. grahami*: IHAS 13200109, 5 specimens, Fuxian Hu, Kunming, Yunnan, China, 246 mm SL; KIZ 7711002, 8312476, 8410701, 3 specimens, 395–426 mm SL. *S. lanzhouensis*: IHAS 13200115, 5 specimens, Gansu, China, 150–174 mm SL; IHAS, 3 type specimens (radiograph), Lanzhou, Gansu, China, 127–271 mm SL. *S. lithophilus*: FBKU, uncatalogued, 9 specimens, Lake Biwa, Japan, 124–411 mm SL. *S. mento*: HIAS 3200106, 3200115, 18 specimens, Dian Chi, Kunming, Yunnan, China, 66.6–312 mm SL; KIZ 00084, 1 specimen, Dian Chi, Kunming, Yunnan, China, 256 mm SL. *S. meridionalis*: IHAS 13200119, 8 specimens, Yichang, Hubei, China, 52.6–147 mm SL; IHAS 13200129, 1 specimen, Cheng Hai, Kunming, Yunnan, China, 249.1 mm SL; IHAS 13200132, 2 specimens, Hechuang, Sichuang, China, 92.4 mm and 106 mm SL, 1 specimen, Yichang, Hubei, China, 264 mm SL; 1 specimen, Wan Xian, Sichusang, China, 342 mm SL, 1 specimen, Jiangjin, Sichuang, China, 296 mm SL, 1 specimen, Fuling, Sichuang, China, 318 mm SL; IHAS 63VII77, 1 specimen, Wuchang, Hubei, China, 394 mm SL. *S. microdorsalis*: NSMT 50245, 9 specimens, Younkok River, Gule, South Korea, 117–189 mm SL; NSMT-P 50246, 4 specimens, Namdae River, Yangyang, South Korea, 115–163 mm SL; NSMT 50247, 1 specimen, Hangang River, South Korea, 134 mm SL. *S. soldatovi*: ZUMT 55084, 1 specimen, Manchuria, China, 249 mm SL; IHAS 13200123, 6 specimens, China, 216–283 mm SL; IHAS 13200117, 5 specimens, Liao He, China, 52.4–147 mm SL. *S. torrentis* sp. nov.: NIFI 00414, 3 specimens, Krating Waterfall, Chantaburi, Thailand, 168–198 mm SL; NIFI, uncatalogued, locality unknown, 2 specimens, 130 mm and 167 mm SL; NSMT-P 50234–50239, 7 type specimens, Lampae Stream, Trang, Thailand, 92.0–179 mm SL; NSMT-P 50240–50242, 3 specimens, Krating Waterfall, Chantaburi, Thailand, 161–187 mm SL; FBKU, uncatalogued, 3 specimens, Lampae Stream, Trang, Thailand, 101–161 mm SL; FBKU, uncatalogued, 2 specimens, Klong Bang Son, Trang, Thailand, 146 mm and 161 mm SL; NHRM MAL/1934. 168. 3225, 7 specimens, Patao, Kachin State, Burma, 88.6–160 mm SL; NHRM MAL/1934. 467. 5007, 3 specimens, Mahlwedaung, Ye State, Burma, 150–178 mm SL. *S. triostegus*: BMNH 1920. 3. 3: 168–176, 3 specimens, Basrah, Iraq, 205–220 mm SL. *S. wynaadensis*: BMNH 1889. 2. 1. 2512–2522, 1 specimen, Madras, India, 79.5 mm SL, syntype.

The terminology of the skull elements follows Patterson (1975), the suspensorial bones Lundberg (1970) and Howes (1983), the caudal skeleton

Fig. 1. *Silurus afghana*, BMNH 1860.3.19: 755, 110 mm SL.

Lundberg and Baskin (1969), and the shoulder girdle Brousseau (1976).

The colouration of the specimens is described under the preserved condition unless otherwise noted. Morphometric values are given by mean ±standard deviation ($\bar{x}\pm SD$).

The phyletic analysis was undertaken on the basis of cladistic methods (Hennig, 1966; Wiley, 1981).

Genus *Silurus* Linnaeus, 1758

Silurus Linnaeus, 1758: 304 (type species, *Silurus glanis* Linnaeus, 1758, by Bleeker's (1862) subsequent designation).

Glanis Agassiz, 1856: 333 (type species, *Glanis aristotelis* Agassiz, 1856, by monotypy).

Parasilurus Bleeker, 1862: 392 (type species, *Silurus japonicus* Temminck et Schlegel, 1847, by original designation).

Herklostella Herre, 1933: 179 (type species, *Herklostella anomala* Herre, 1933, by original designation).

Dorsal fin rays 1–6; pectoral fin rays I, 8–16; pelvic fin rays i, 6–12; anal fin rays 56–88; total vertebrae 52–74; branchiostegals 10–17; gill rakers 2–16.

This genus is differentiated from other silurids by the following sets of characteristics: dorsal fin very small; anal fin confluent with caudal fin with a distinct notch between them; anterior surface of pectoral spine smooth, granulated, or serrated, but its posterior surface strongly serrated in males and weakly serrated or smooth in females; lower jaw longer or shorter than the upper; eyes not visible from underside of head, covered with skin, or surrounded with a free orbital rim and lying above level of corner of mouth; maxillary barbels well developed and extending over gill opening; mandibular barbels two or four.

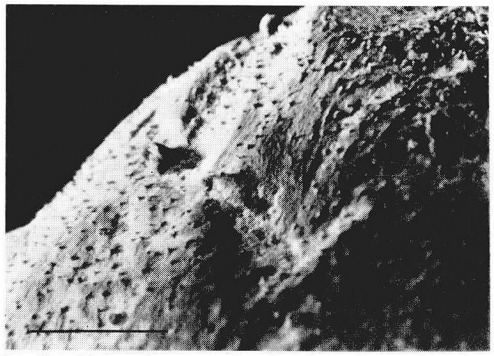

Fig. 2. Tubercles on the head region of *Silurus afghana*. Scale bar indicates 3 mm.

Distribution. Eurasia.

Silurus afghana Günther, 1864
(Fig. 1)

Silurus afghana Günther, 1864: 34; Day, 1878: 481.
Silurus dukai Day, 1873: 239.

No specimen was dissected.

Dorsal fin rays 2; pectoral fin rays I, 11; pelvic fin rays i, 8; anal fin rays 74; caudal fin rays 7+8; vertebrae 15+45=60.

Upper jaw longer than lower; head 5.26 in standard length; numerous minute tubercles scattered on body surface, especially abundant on head region (Fig. 2); head remarkably flat; snout rounded; eye without free orbital rim and covered with skin; whole body uniformly dark brown; vomerine tooth band separated into a pair of patches; mesethmoid slender and narrowed at base of its slender lateral process.

Fig. 3. *Silurus aristotelis*, NSMT-P 50248, 227 mm SL.

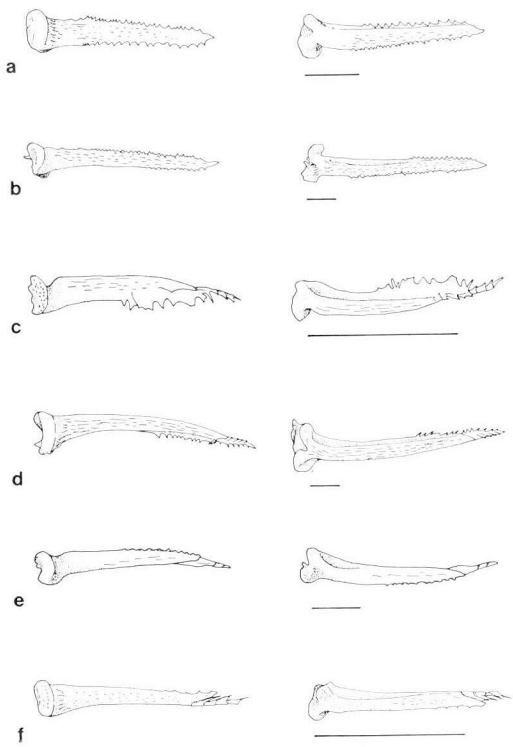

Fig. 4. Right pectoral spine. Left row dorsal view, and right row ventral view. Upper side in left row shows anterior. a, *Silurus aristotelis*; b, *S. biwaensis*; c, *S. cochinchinensis*; d, *S. glanis*; e, *S. grahami*; f, *S. microdorsalis*. Scale bars indicate 1 cm.

Distribution. Afghanistan.

Silurus aristotelis (Agassiz, 1856)
(Fig. 3)

Glanis aristotelis Agassiz, 1856: 333.
Silurus aristotelis: Garman, 1890: 8; Haig, 1950: 97.
Parasilurus aristotelis: Hoffman and Jordan, 1892: 241; Thompson, 1947: 46.

One specimen (227 mm SL) was dissected for anatomical study.

Dorsal fin rays 2, 3; pectoral fin rays I, 11; pelvic fin rays i, 8; anal fin rays 75; caudal fin rays 7+7–8; vertebrae 15+45, 46=70, 71; branchiostegals 13; gill rakers 2, 3+11, 13.

Lower jaw longer than upper; head 4.1 in standard length; whole body mottled black and white; a single pair of mandibular barbels; maxillary barbel extending beyond operculum but not reaching tip of pectoral fin; anterior margin of pectoral spine strongly serrated (Fig. 4a); vomerine tooth band widely separated into a pair of patches (Fig. 5b).

Skull (Fig. 5): Anterior margin of mesethmoid curved gently and antero-median indention not remarkable; posterior part of frontal and supraoccipital rising gently; sagittal crest confined to posterior part of supraoccipital.

Suspensorium (Fig. 6): Hyomandibular process well developed as a small pterygoid process separating adductor mandibulae and levator arcus palatini muscles.

Shoulder girdle (Fig. 7): Upper part of anterior half of cleithrum inwards with a ridge; ventral coracoid lamina extending ventrally; coracoid connected with cleithrum without forming a complex suture.

Caudal skeleton (Fig. 8): All hypurals separated from each other; hypurapophysis and secondary hypurapophysis poorly developed, and not fused with each other; secondary hypurapophysis forming a shelf on hypural 1.

Distribution. Balkan Peninsula of Greece.

Silurus asotus Linnaeus, 1758
(Fig. 9)

Silurus asotus Linnaeus, 1758: 304; Haig, 1950: 97; Chen, 1977: 205.
Silurus punctatus Cantor, 1842: 485.

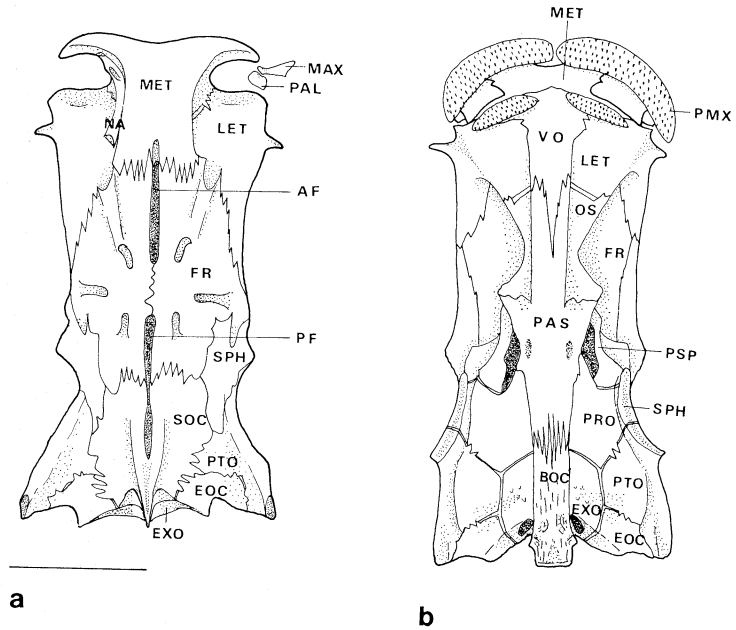

Fig. 5. Skull of *Silurus aristotelis*. a, dorsal view; b, ventral view. AF, anterior fontanel; BOC, basioccipital; EOC, epioccipital; EXO, exoccipital; FR, frontal; LET, lateral ethmoid; MAX, maxilla; MET, mesethmoid; NA, nasal; OS, orbitosphenoid; PAL, palatine; PF, posterior fontanel; PMX, premaxilla; PRO, prootic; PTO, pterotic; SOC, supraoccipital; SPH, sphenotic; VO, vomer. Scale bar indicates 1 cm.

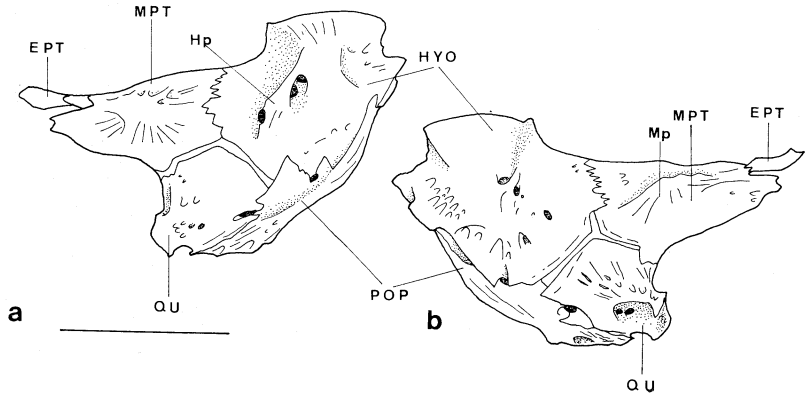

Fig. 6. Suspensorium of *Silurus aristotelis*. a, lateral view; b, medial view. EPT, entopterygoid; HYO, hyomandibular; Hp, hyomandibular process; MPT, metapterygoid; POP, preopercular; Qp, quadrate process; QU, quadrate. Scale bar indicates 1 cm.

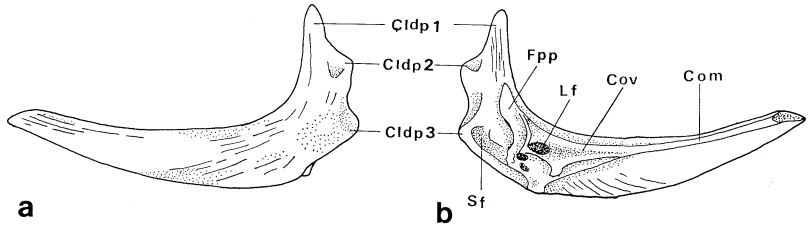

Fig. 7. Shoulder girdle of *Silurus aristotelis*. a, lateral view; b, medial view. Pectoral fin is removed. Cldp 1–3, dorsal prong of cleithrum 1–3; Com, medial coracoid lamina; Cov, ventral coracoid lamina; Fpp, foot-plate of primary girdle; Lf, locking foramen of primary girdle; Sf, spinal fossa of cleithrum. Scale bar indicates 1 cm.

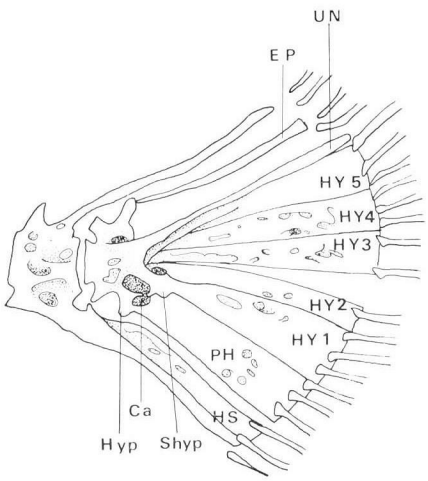

Fig. 8. Caudal skeleton of *Silurus aristotelis*. Ca, point of emergence of caudal artery; Ep, epural; HS, haemal spine; HY 1–5, hypurals 1–5; Hyp, hypurapophysis; PH, parhypural; Shyp, secondary hypurapophysis; UN, uroneural. Scale bar indicates 1 cm.

Silurus japonicus Temminck and Schlegel, 1847: 226.
Parasilurus japonicus: Bleeker, 1862: 392.
Silurus cinereus Dabry de Thiersant, 1872: 189.
Parasilurus asotus: Abbott, 1901: 483; Uchida, 1943: 2.
Silurus bedfordi Regan, 1908: 59.
Parasilurus asotus asotus: Nichols, 1943: 34.
Parasilurus sp.: Liu, 1965: 99.

Nine specimens from Lake Biwa (132–458 mm SL) were dissected for anatomical study.

Lake Biwa (N=9): Dorsal fin rays 4–6; pectoral fin rays I, 10–13; pelvic fin rays i, 10–11; anal fin rays 71–88; caudal fin rays 6–8+6–7; vertebrae 13–15+46–50=60–64; branchiostegals 13–16; gill rakers 1–3+8–10.

Korea (N=14): Dorsal fin rays 4–5; pectoral fin rays I, 10–13; pelvic fin rays i, 8–10; anal fin rays 59–82; caudal fin rays 7–8+7–8; vertebrae 12–15+45–50=59–64; branchiostegals 13–16; gill rakers 0–3+6–10.

China (N=14): Dorsal fin rays 4–6; pectoral fin rays I, 10–13; pelvic fin rays i, 9–11; anal fin rays 70–85; caudal fin rays 6–8+7–8; vertebrae 13–15+46–50=60–64; branchiostegals 13–16; gill rakers 1–2+6–10.

Taiwan (N=1): Dorsal fin rays 4; pectoral fin rays I, 13; pelvic fin rays i, 11; anal fin rays 79; caudal fin rays 7+7; vertebrae 14+49=63; branchiostegals 13; gill rakers 2+10.

Lower jaw longer than the upper; head 4.78±0.1 (Lake Biwa), 4.57±0.25 (Korea), 4.45±0.44 (China), and 4.37 (Taiwan) in standard length; eye surrounded by a free orbital rim; body in life completely mottled dorsally and sparsely marbled ventrally; one pair of mandibular barbels; maxillary barbel extending beyond pectoral fin; lateral line arranged in several rows horizontally as well as vertically; anterior margin of pectoral spine strongly serrated; three types of vomerine tooth band—1) gently curved continuous band, 2) continuous band with its posterior margin notched forward at a sharp angle, and 3) band of very narrowly separated patches. Most of the specimens (Lake Biwa: 88.9%) represent the first type.

Skull: Indention of antero-median part of mesethmoid narrow and deep; sagittal crest broad but not prominent, rising from posterior part of frontal.

Suspensorium: Hyomandibular process forming a ridge for attachment of adductor mandibulae 3 and levator arcus palatini; entopterygoid rod-like, connected to postero-lateral margin of vomer by a ligament.

Shoulder girdle: Cleithrum bending inward forming a vertical ridge; ventral coracoid lamina poorly developed; coracoid connected with cleithrum without forming a complex suture.

Caudal skeleton (Fig. 10): Three types of fusion of hypural bones—1) all hypurals separated from each other, both hypurapophysis and secondary

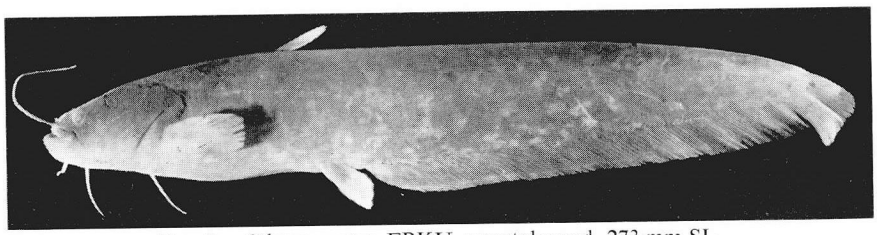

Fig. 9. *Silurus asotus*, FBKU, uncatalogued, 273 mm SL.

hypurapophysis poorly developed, and secondary hypurapophysis forming a shelf on hypural 1, 2) hypurals 3, 4 and 5 fused with each other, both hypurapophysis and secondary hypurapophysis poorly developed, 3) parhypural bone fused with hypurals 1 and 2, uroneural fused with hypurals 3, 4 and 5 (a small hypurapophysis is observed in this type). The first type occurred in 89% of the specimens from Lake Biwa. The radiograph of the holotype of *S. bedfordi* was examined. Vertebrae 14+48=62; anal fin rays 73. Anterior surface of pectroal spine serrated. Three characters fell within the variation range of *S. asotus*.

Distribution. Eastern Asia.

Silurus biwaensis (Tomoda, 1961)
(Fig. 11)

Parasilurus biwaensis Tomoda, 1961: 348.

All the specimens were dissected for anatomical inspection.

Dorsal fin rays 4–6; pectoral fin rays I, 13–15; pelvic fin rays i, 9–12; anal fin rays 71–83; caudal fin rays 6–7+7–9; vertebrae 13–17+49–52=63–68; branchiostegals 14–16; gill rakers 2–3+9–12.

Lower jaw prominently longer than upper; head 4.28±0.15 in standard length; dorsal surface of body black and ventral surface white; a single pair of mandibular barbels, rather short and feeble; maxillary barbels not reaching base of pectoral fin in adult, but reaching about half of pectoral fin in juveniles or young specimens; outer surface of pectoral spine granulated (Fig. 4b); upper lobe of caudal fin longer than lower; vomerine teeth in one continuous band whose posterior margin is sharply indented.

Skull: Depression in anterior border of mesethmoid rather weak, forming a gentle curve; sagittal crest originating from posterior one-third of the frontal, and vertically elevated on the posterior part of skull; free margin of pterotic bending upwards and forming a depression for origin of epaxial muscles.

Suspensorium: Hyomandibular process to which adductor mandibulae 3 and levator arcus palatini attach forming a horizontal ridge in front of facial canal; developed quadrate process to which levator arcus palatini attaches connecting to hyomandibular process.

Shoulder girdle: Outer surface of cleithrum

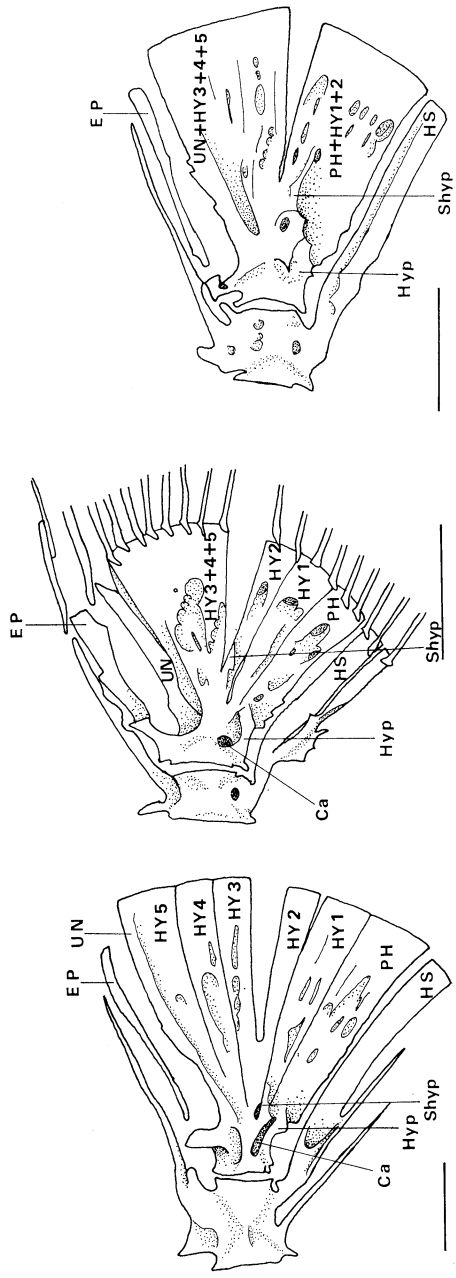

Fig. 10. Three types of caudal skeleton of *Silurus asotus*. Abbreviations as in Fig. 8. Scale bars indicate 1 cm.

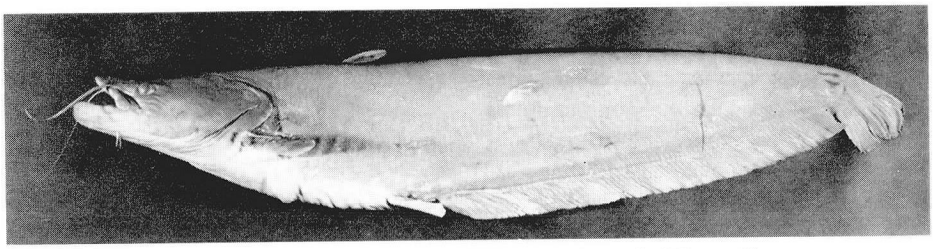

Fig. 11. *Silurus biwaensis*, FBKU, uncatalogued, 672 mm SL.

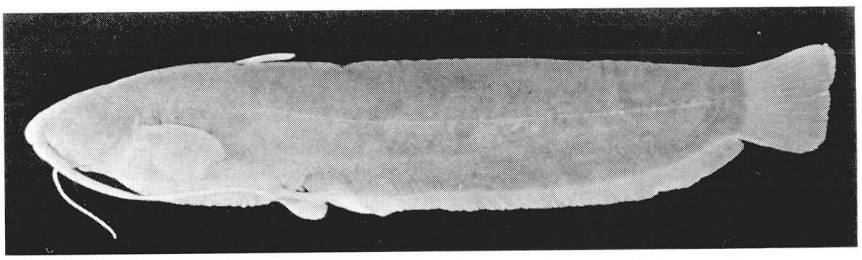

Fig. 12. *Silurus cochinchinensis*, FBKU, uncatalogued, 82 mm SL.

nearly flat; pterygoid process of coracoid remarkably developed ventrally; coracoid connected with cleithrum without forming a suture.

Caudal skeleton: Hypurals not fused; both hypurapophysis and secondary hypurapophysis well developed; the former almost reaching the latter and forming a ring-like bridge; secondary hypurapophysis forming a shelf on hypurals 1 and 2.

Distribution. Endemic to Lake Biwa Basin, Japan.

Silurus cochinchinensis
Valenciennes, 1839
(Fig. 12)

Silurus cochinchinensis Valenciennes in Cuvier and Valenciennes, 1839: 352; Günther, 1864: 34; Haig, 1950: 99; Chen, 1977: 202.

Silurus punctatus (not of Cantor, 1842): Day, 1868: 155.

Parasilurus cochinchinensis: Nichols, 1943: 35.

Five specimens (60.3–156 mm SL) were dissected for anatomical study.

Dorsal fin rays 4; pectoral fin rays I, 8–10; pelvic fin rays i, 7–8; anal fin rays 58–66; caudal fin rays 6–7+7–8; vertebrae 11–13+41–45=53–57; branchiostegals 10–14; gill rakers 0–3+3–4.

Upper jaw longer than lower; head 5.27±0.41 in standard length; mandibular barbels a single pair and longer than head (specimens less than 65 mm SL had two pairs); maxillary barbel extending beyond base of pectoral fin, not reaching its tip in adult but extending beyond pectoral fin in juvenile or young specimens; dorsal surface of body mottled brown, with border of anal fin white; eye covered with skin and without rim; caudal fin nearly truncated; anterior surface of pectoral spine completely smooth (Fig. 4c), with posterior surface serrated (serration more remarkable in males); gill raker long and slender; testis branched into thin lobes; vomerine tooth band separated into a pair of small patches.

Skull (Fig. 13): Base of lateral process of mesethmoid narrowed remarkably; posterior part of skull not elevated, sagittal crest absent, and broad rise formed in the postero-median part of supraoccipital where epaxial muscles originate; skull roof in frontal region completely flattened.

Suspensorium (Fig. 14): Hyomandibular process well developed, forming a pterygoid process separating adductor mandibulae 3 and levator arcus palatini; entopterygoid not rod-like but a long sheet of bone.

Shoulder girdle (Fig. 15): Ventral coracoid lamina poorly developed; vertical part of cleithrum short and bending inward with a ridge; coracoid connected without forming a complex suture.

Caudal skeleton (Fig. 16): Hypurals not fused with each other, but base of hypurals 3,4 and 5

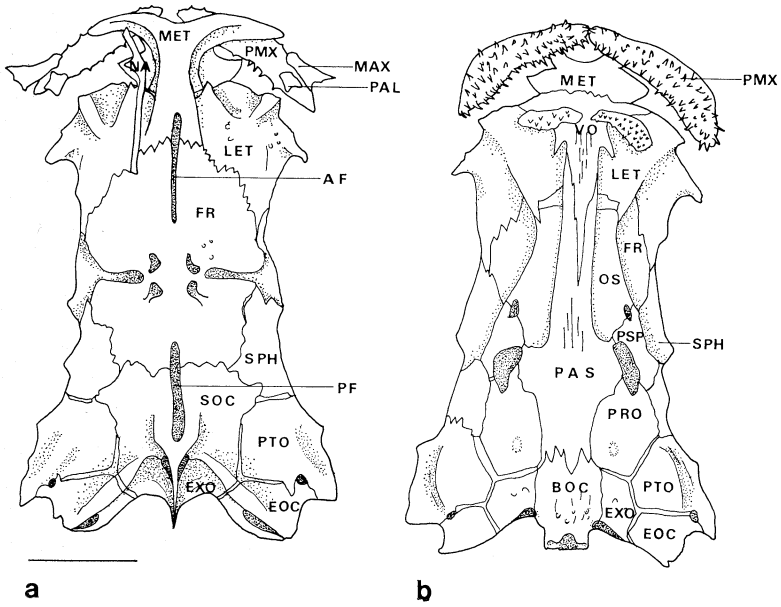

Fig. 13. Skull of *Silurus cochinchinensis*. a, dorsal view; b, ventral view. Abbreviations as in Fig. 5. Scale bar indicates 1 cm.

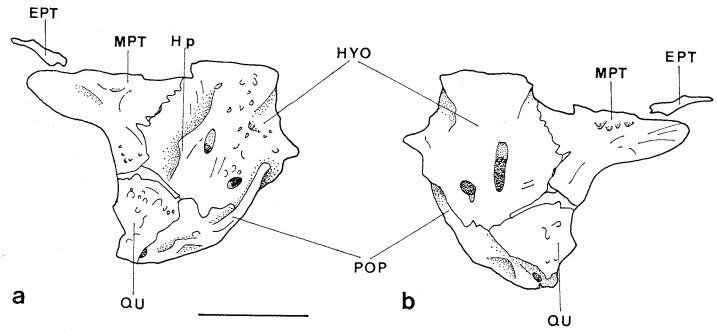

Fig. 14. Suspensorium of *Silurus cochinchinensis*. a, lateral view; b, medial view. Abbreviations as in Fig. 6. Scale bar indicates 1 cm.

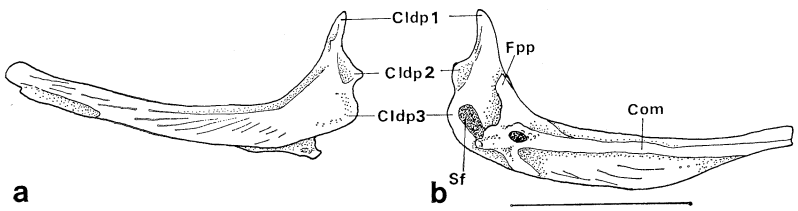

Fig. 15. Shoulder girdle of *Silurus cochinchinensis*. a, lateral view; b, medial view. Pectoral fin is removed. Abbreviations as in Fig. 7. Scale bar indicates 1 cm.

partially fused ; hypurapophysis not developed, secondary hypurapophysis forming small pterygoid process on hypural 2.

Distribution. Eastern China and Thailand.

Silurus gilberti Hora, 1938
(Fig. 17)

Silurus wynaadensis (not of Day, 1873): Tchang, 1936: 35.

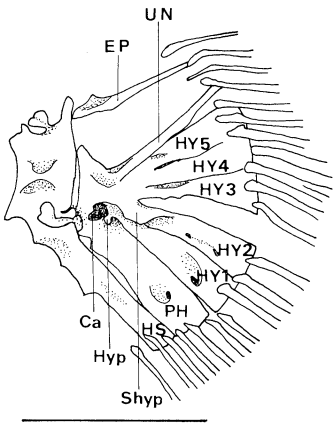

Fig. 16. Caudal skeleton of *Silurus cochinchinensis*. Abbreviations as in Fig. 8. Scale bar indicates 1 cm.

Silurus sinensis (not of McLelland, 1844): Hora, 1937: 341.

Silurus gilberti Hora, 1938: 351; Haig, 1950: 100; Chen, 1977: 201.

One specimen (120 mm SL) was dissected for anatomical study.

Dorsal fin rays 4; pectoral fin rays I, 10–11; pelvic fin rays i, 7–8; anal fin rays 57–66; caudal fin rays 5–7+7–8; vertebrae 11–12+39–42=50–54; branchiostegals 10–12; gill rakers 0–1+4–6.

Upper jaw slightly longer than lower; head 5.25±0.19 in standard length; whole body mottled with black and brown, with paler ventral surface; border of anal fin white; mandibular barbel usually two pairs (in six out of seven specimens), and rarely one pair; longer mandibular barbel reaching base of pectoral fin but not extending beyond it; maxillary barbel extending over pectoral fin, almost reaching tip of ventral fin; anterior edge of pectoral spine smooth; caudal fin almost truncated; eye covered with skin and not with free orbital rim; needle-like gill rakers poorly developed; testis branched into slender ribbons from its basement.

Skull: Base of lateral process of mesethmoid narrowed remarkably; posterior part of supraoccipital having a broad and low crest for origin of epaxial muscles; frontal completely flat, and posterior part of supraoccipital and epioccipital forming a bump and a small depression for origin of epaxial muscles; posterolateral part of vomer having a small process with which entopterygoid is connected by a ligament; supraorbital canal on frontal not forming a complete canal but a mere groove.

Suspensorium: Hyomandibular process poorly developed; entopterygoid rather large and forming a flat sheet.

Shoulder girdle: Cleithrum slightly curved, with short horizontal part; ventral coracoid lamina poorly developed; coracoid connected with cleithrum without forming a suture.

Caudal skeleton: Hypurals 1 and 2 fused with each other; hypurapophysis fused with well-developed secondary hypurapophysis, forming a bridge; secondary hypurapophysis forming a shelf on hypurals 1 and 2.

Distribution. Hainan, China.

Silurus glanis Linnaeus, 1758

Silurus glanis Linnaeus, 1758: 304; Berg, 1949: 470; Haig, 1950: 100; Nikolsky, 1961: 307.

One specimen (NSMT-P 50244) was dissected.

Dorsal fin rays 3–4; pectoral fin rays I, 15–16; pelvic fin rays i, 11–12; anal fin rays 83–87; caudal fin rays 7+8; vertebrae 18–19+54–56=72–74; branchiostegals 15–16; gill rakers 2+10.

Lower jaw longer than upper; head 4.65 in standard length; body well mottled even on ventral surface; adult retains two pairs of mandibular barbels; outer surface of pectoral spine smooth, and inner surface serrated (Fig. 4d); eyes with free orbital rim; vomerine tooth band broad and continuous; posterior margin of the band angularly indented.

Skull: Skull remarkably narrowed at level of lateral process of sphenotic; antero-median part of mesethmoid indented posteriorly; mesethmoid broad and not narrowed at base of its lateral process; wide and low sagittal crest elevated from posterior half of frontals.

Suspensorium: Small bump to which the levator arcus palatini attaches formed just in front of facial canal on hyomandibular, but no process on quadrate.

Shoulder girdle: Cleithrum curving gently, rather flat, but not as flat as in *S. biwaensis*; pterygoid process of coracoid not extending horizontally but bending dorsally; coracoid connected with cleithrum without forming a suture.

Caudal skeleton: All hypural bones separated from each other; hypurapophysis and secondary hypurapophysis not fused with each other; secondary hypurapophysis forming a shelf on hypu-

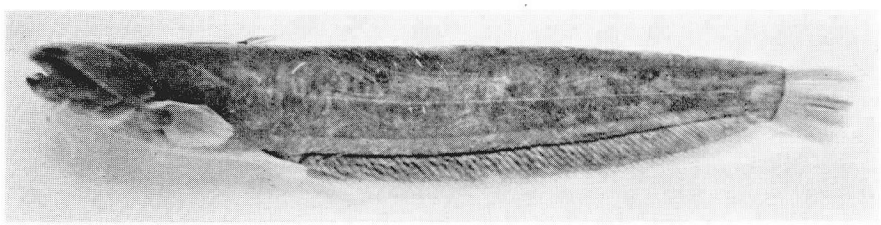

Fig. 17. *Silurus gilberti*, IHAS 13200103, 120 mm SL.

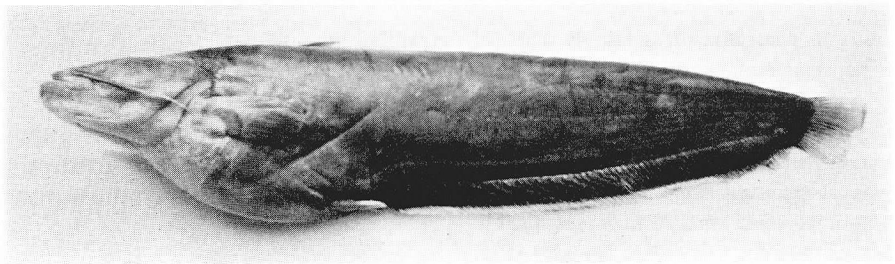

Fig. 18. *Silurus grahami*, KIZ 7711002, 426 mm SL.

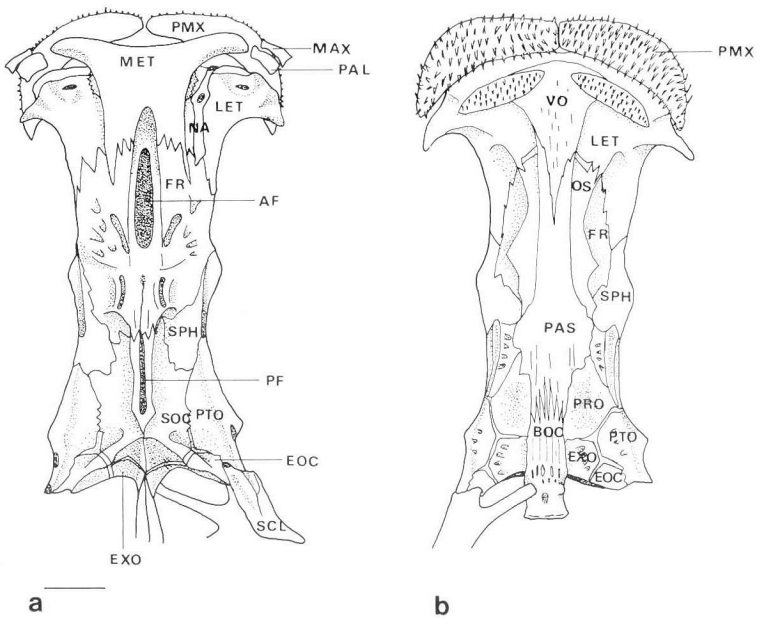

Fig. 19. Skull of *Silurus grahami*. a, dorsal view; b, ventral view. Abbreviations as in Fig. 5. Scale bar indicates 1 cm.

ral 1.

Distribution. Europe, Asia Minor, and Central Asia.

Silurus grahami Regan, 1907
(Fig. 18)

Silurus grahami Regan, 1907: 64.

Silurus mento grahami: Chen, 1977: 205.

One specimen (395 mm SL) was dissected.

Dorsal fin rays 4–5; pectoral fin rays I, 10–12; pelvic fin rays i, 8–10; anal fin rays 67–75; caudal fin rays 7–8+7–8; vertebrae 14–15+46–49=61–63; branchiostegals 13–15; gill rakers 1–2+8–11.

Lower jaw longer than upper; head 4.35±0.14 in standard length; maxillary barbel never extend-

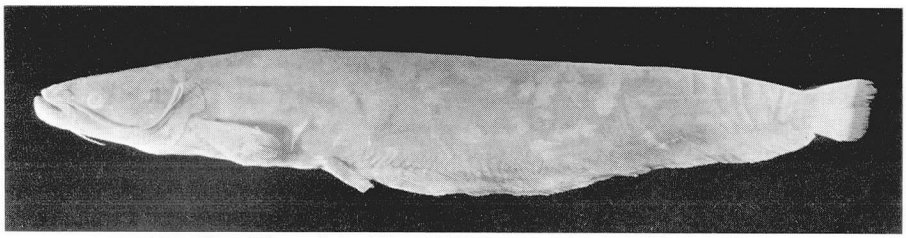

Fig. 20. *Silurus lithophilus*, FBKU, uncatalogued, 212 mm SL.

ing over half of pectoral fin; a single pair of mandibular barbels; remarkable horizontal lateral lines on body surface in addition to vertical one running along middle of body; dorsal surface of body slightly mottled and ventral surface white; outer surface of pectoral spine granulated in a single row, and its inner surface in males weakly serrated, but completely smooth in females (Fig. 4e); upper lobe of caudal fin slightly longer than lower; vomerine teeth in two widely separated patches.

Skull (Fig. 19): Indention of antero-median part of mesethmoid very weak and its anterior border forming a gentle curve; posterior end of supraoccipital and epioccipital elevated and forming depression for epaxial muscles.

Suspensorium: Small process for insertion of adductor mandibulae 3 and origin of levator arcus palatini formed in front of facial foramen.

Shoulder girdle: Cleithrum bending medially; pterygoid process of coracoid not remarkable; coracoid connected with cleithrum without a complex suture.

Caudal skeleton: Hypurapophysis and secondary hypurapophysis well developed but not fused with each other; secondary hypurapophysis forming a shelf on hypural 1.

Distribution. Endemic to Yunnan, China.

Silurus lanzhouensis Chen, 1977

Silurus lanzhouensis Chen, 1977: 210.

No specimen was dissected for anatomical inspection, but one specimen was skinned in the skull roof region to examine the shape of the mesethmoid and sagittal crest of the supraoccipital. Considering that this species grows over 1 m, the specimens observed here were young.

Dorsal fin rays 4–5; pectoral fin rays I, 11–13; pelvic fin rays i, 8–10; anal fin rays 70–88; caudal fin rays 7–8+6–8; vertebrae 16+52–53=68–69 (radiographs of three type specimens); branchiostegals 13–15; gill rakers 1–2+8–11.

Lower jaw longer than upper, head 4.55±0.37 in standard length; eye with free orbital rim; body sparsely mottled in preserved specimens; anterior surface of pectoral spine granulated in a single row; a single pair of mandibular barbels; maxillary barbel reaching tip of pectoral fin; upper lobe of caudal fin slightly longer than, or as long as lower one; vomerine teeth in two closely separate patches, lateral projection of mesethmoid short and slender; sagittal crest rising from supraoccipital and not well-developed; posterior end of epioccipital and supraoccipital elevated, forming depression for origin of epaxial muscles.

Distribution. Upper Yellow River Basin, China.

Silurus lithophilus (Tomoda, 1961)
(Fig. 20)

Parasilurus lithophilus Tomoda, 1961: 350.

All specimens were dissected for anatomical study.

Dorsal fin rays 4–5; pectoral fin rays I, 10–12; pelvic fin rays i, 9–11; anal fin rays 77–82; caudal fin rays 7–8+7–8; vertebrae 14–15+48–55=62–66; branchiostegals 14–17; gill rakers 1–2+8–10.

Lower jaw longer than upper; head 4.62±0.23 in standard length; golden brown patterns scattered on lateral and dorsal sides of body, and ventral surface of body sparsely mottled with black and white spots in life; a single pair of mandibular barbels; maxillary barbel extending beyond half of pectoral fin, but never reaching its tip in adults (extending beyond tip of pectoral fin in young); length of upper and lower lobes of rounded caudal fin nearly equal; pectoral spine strongly serrated; vomerine tooth band separated into a pair of close-lying patches.

Skull: Antero-median part of mesethmoid indented deeply; sagittal crest broad and not pro-

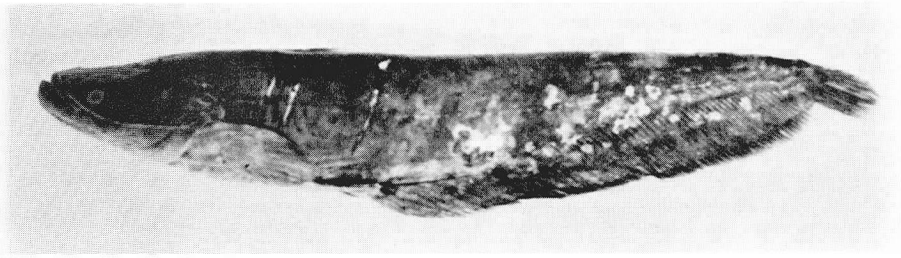

Fig. 21. *Silurus mento*, IHAS 3200106, 213 mm SL.

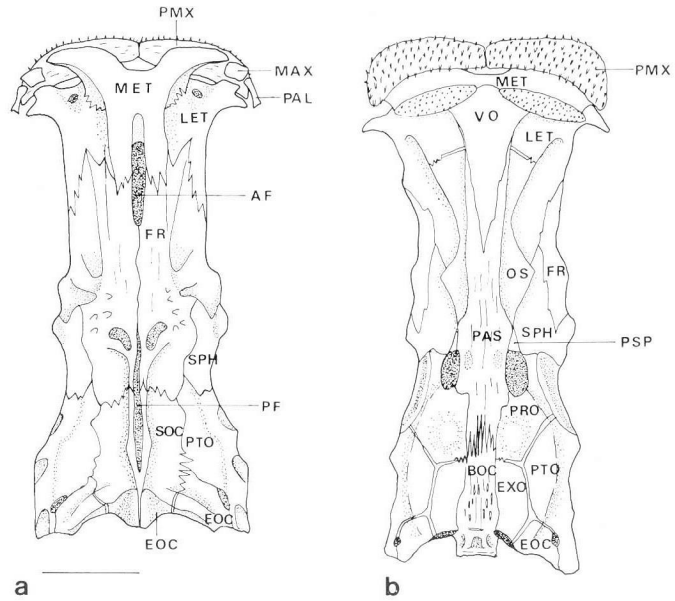

Fig. 22. Skull of *Silurus mento*. a, dorsal view; b, ventral view. Abbreviations as in Fig. 5. Scale bar indicates 1 cm.

minent, rising from middle of frontal, and posteromedian part of skull elevated gently.

Suspensorium: Hyomandibular process poorly developed, continuing to quadrate process where levator arcus palatini attaches.

Shoulder girdle: Upper half of anterior part of cleithrum bending inward and forming a ridge; ventral coracoid lamina well developed horizontally; coracoid connected with cleithrum without a complex suture.

Caudal skeleton: Hypurals not fused with each other; both hypurapophysis and secondary hypurapophysis poorly developed; secondary hypurapophysis forming a shelf on hypural 1.

Distribution. Endemic to Lake Biwa Basin, Japan.

Silurus mento Regan, 1904
(Fig. 21)

Silurus mento Regan, 1904: 192; Haig, 1950: 100; Chen, 1977: 203.

Parasilurus mento: Nichols, 1943: 34.

One specimen (KIZ 00084) was dissected for anatomical inspection.

Dorsal fin rays 3–4; pectoral fin rays I, 9–11; pelvic fin rays i, 7–9; anal fin rays 61–73; caudal fin rays 6–7+6–8; vertebrae 12–15+41–46=54–60; branchiostegals 12–15; gill rakers 2–3+9–13.

Lower jaw longer than upper; head 4.11±0.21 in standard length; a single pair of mandibular barbels, but two pairs in young specimens less than 80 mm SL; maxillary barbel rather short and not reaching end of opercle; outer margin of

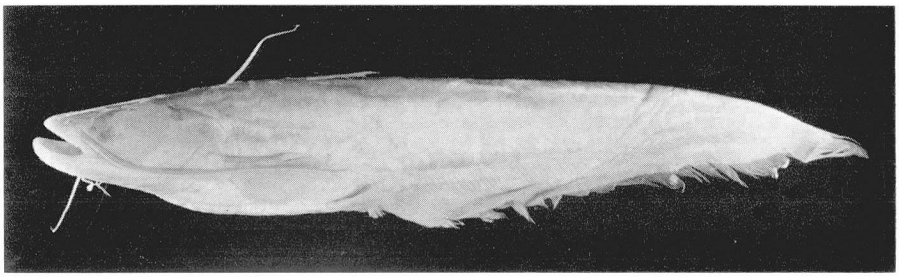

Fig. 23. *Silurus meridionalis*, FBKU, uncatalogued, 182 mm SL.

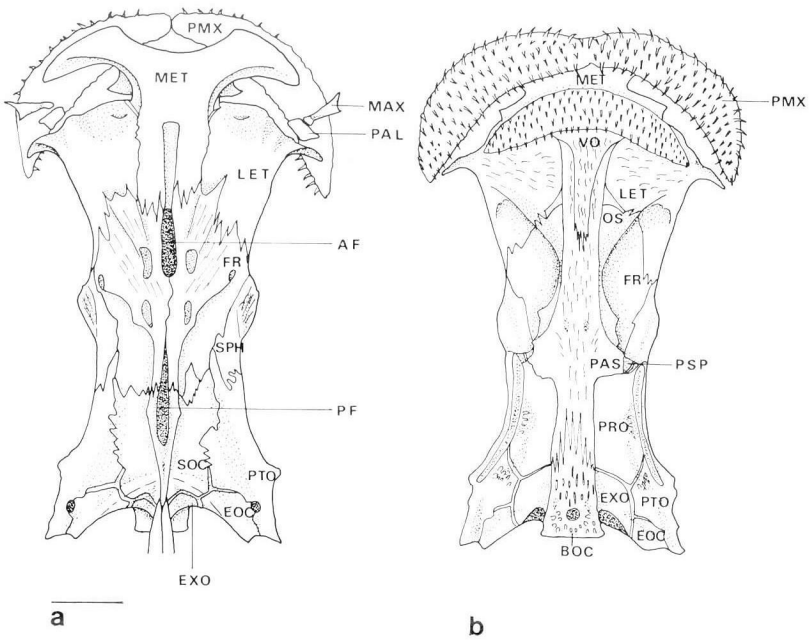

Fig. 24. Skull of *Silurus meridionalis*. a, dorsal view; b, ventral view. Abbreviations as in Fig. 5. Scale bar indicates 1 cm.

pectoral spine granulated in a single row; body depth suddenly decreasing, and a slight depression formed at caudal peduncle in lateral aspect; whole body surface mottled with black finger patterns in preserved specimens, but sparse on ventral surface of body; in addition to vertical line several horizontal lateral lines distributed on dorsal and lateral body surface; vomerine teeth in two separated patches.

Skull (Fig. 22): Antero-median part of mesethmoid indented backward remarkably; sagittal crest, broad and not prominent, beginning from posterior end of frontals.

Suspensorium: Hyomandibular process lacking, but small edge of bump formed in front of facial canal.

Shoulder girdle: Ventral part of coracoid forming a horizontal pterygoid process, but its median part slender; coracoid connected with cleithrum without a complex suture.

Caudal skeleton: Hypural bones not fused, and hypurapophysis not remarkable; secondary hypurapophysis developed in triangular process and forming a shelf on hypural 1.

Distribution. Endemic to Yunnan, China.

Silurus meridionalis Chen, 1977
(Fig. 23)

Silurus soldatovi meridionalis Chen, 1977: 210.

One specimen (IHAS 63VII77) was dissected for anatomical study. This species grows over

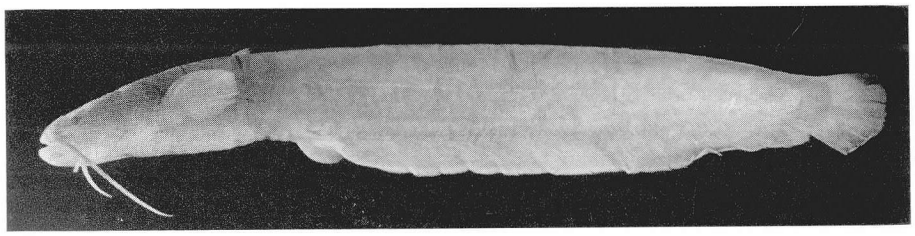

Fig. 25. *Silurus microdorsalis*, FBKU, uncatalogued, 163 mm SL.

1 m when adult stage, but only young of smaller size were available for the present study.

Dorsal fin rays 5–6; pectoral fin rays I, 13–16; pelvic fin rays i, 9–11; anal fin rays 71–85; caudal fin rays 7–8+7–8; vertebrae 15–18+50=64–68; branchiostegals 12–17; gill rakers 3+9.

Lower jaw remarkably longer than upper; head 4.15±0.51 in standard length; dorsal surface of body slightly mottled and brownish; a single pair of mandibular barbels, but two pairs present in younger specimens less than 150 mm SL; maxillary barbels long and extending over pectoral fin but not reaching end of pelvic fin; upper lobe of caudal fin slightly longer than lower; outer margin of pectoral spine granulated; vomerine teeth in one broad continuous band of which posterior margin gently notched.

Skull (Fig. 24): Conspicuously narrowed at level of sphenotic; mesethmoid remarkably broad and its lateral projection well developed; sagittal crest rising from posterior half of frontals.

Suspensorium: Hyomandibular process for insertion of levator arcus palatini and adductor mandibulae 3 forming a sharp edge, and a triangular process for insertion of levator arcus palatini developed on outer surface of quadrate; rod-like entopterygoid connected with metapterygoid posteriorly and with vomer anteriorly by a ligament.

Shoulder girdle: Cleithrum flattened and median part of coracoid not forming a pterygoid process; coracoid connected with cleithrum without forming a complex suture.

Caudal skeleton: Hypurapophysis forming a narrow bridge which is nearly connected with well-developed secondary hypurapophysis; secondary hypurapophysis forming a shelf on hypural 1.

Distribution. Middle Yangtze River Basin, China.

Silurus microdorsalis (Mori, 1936)
(Fig. 25)

Parasilurus microdorsalis Mori, 1936: 671; Uchida, 1943: 9.

Silurus microdorsalis: Haig, 1950: 100.

Two specimens, 115 mm SL and 189 mm SL, were dissected for anatomical study.

Dorsal fin rays 1–3; pectoral fin rays I, 9–11; pelvic fin rays i, 8–10; anal fin rays 61–74; caudal fin rays 7+7–9; vertebrae 13–14+45–47=59–60; branchiostegals 12–13; gill rakers 1+5–7.

Lower jaw slightly longer than upper; head 5.58±0.22 in standard length; a single pair of mandibular barbels; body uniformly dark brown, and the ventral surface, edge of anal and pectoral fins white; caudal fin nearly truncated; eye covered with skin and not with free orbital rim; gill rakers long, as long as the gill filament; pectoral spine short and its anterior surface weakly serrated (Fig. 4f); posterior surface of pectoral spine completely smooth in females, serrated in males; testis branched into many long lobes; vomerine tooth band separated into a pair of distant patches.

Skull (Fig. 26): Lateral process of mesethmoid remarkably long and slender; mesethmoid narrowed at base of its lateral process; sagittal crest confined to posterior part of supraoccipital, thus skull roof completely flattened.

Suspensorium (Fig. 27): Hyomandibular process poorly developed, and quadrate process absent; entopterygoid a long and sheet-like bone.

Shoulder girdle (Fig. 28): Horizontal part of cleithrum very short; ventral coracoid lamina absent; median coracoid lamina sutured with cleithrum.

Caudal skeleton (Fig. 29): Hypurals 1 and 2 fused in larger specimens; neither hypurapophysis nor secondary hypurapophysis present.

Distribution. Korea and the Yalu River, China.

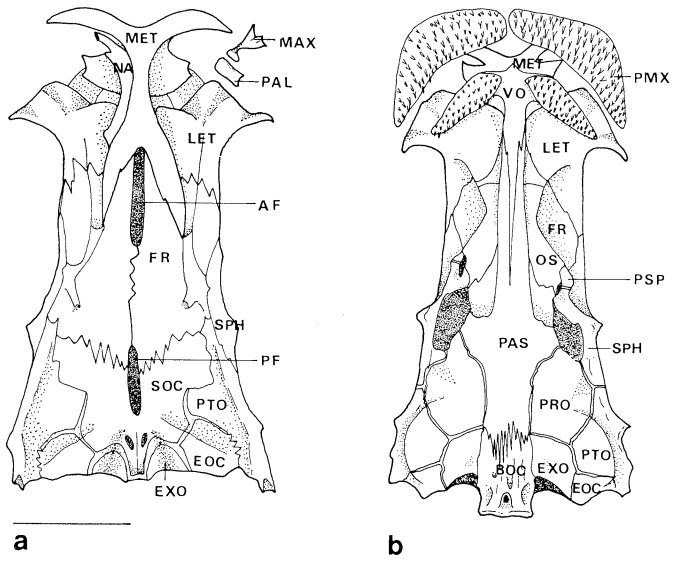

Fig. 26. Skull of *Silurus microdorsalis*. a, dorsal view; b, ventral view. Abbreviations as in Fig. 5. Scale bar indicates 1 cm.

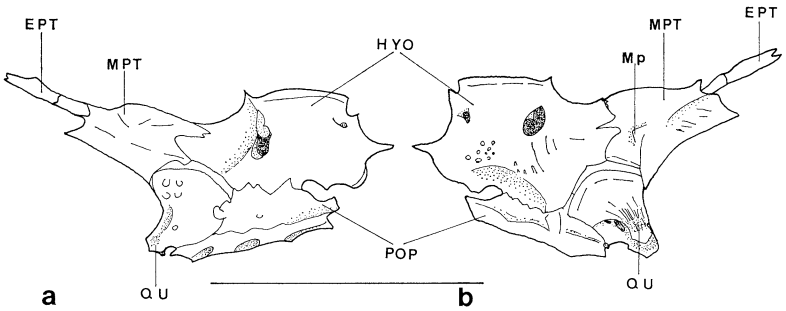

Fig. 27. Suspensorium of *Silurus microdorsalis*. a, lateral view; b, medial view. Abbreviations as in Fig. 6. Scale bar indicates 1 cm.

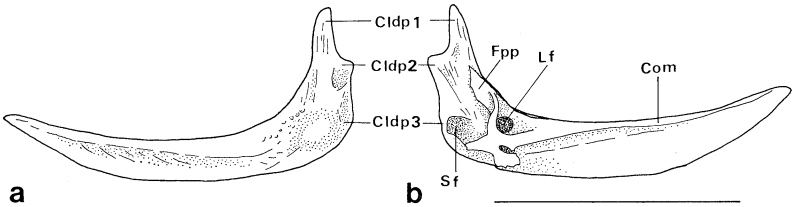

Fig. 28. Shoulder girdle of *Sliurus microdorsalis*. a, lateral view; b, medial view. Pectoral fin is removed. Abbre7iations as in Fig. 7. Scale bar indicates 1 cm.

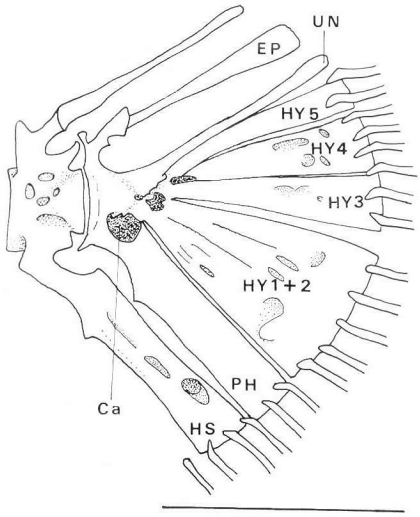

Fig. 29. Caudal skeleton of *Silurus microdorsalis*. Abbreviations as in Fig. 8. Scale bar indicates 1 cm.

Fig. 31. Tip of maxillary barbels in *Silurus soldatovi*. Scale bar indicates 1 cm.

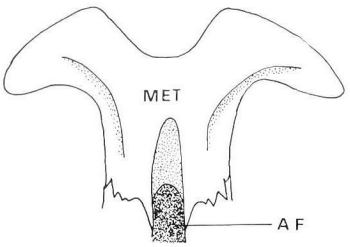

Fig. 32. Dorsal view of mesethmoid of *Silurus soldatovi*. Abbreviations as in Fig. 5.

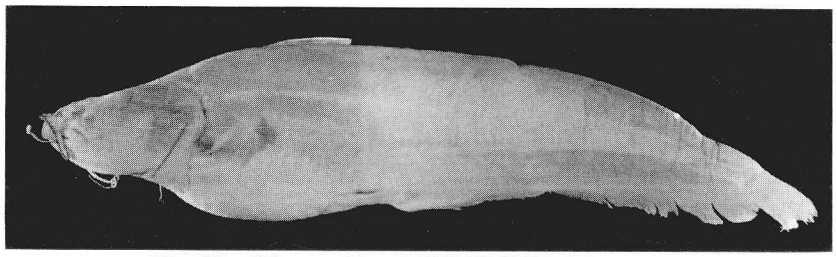

Fig. 30. *Silurus soldatovi*, ZUMT 55084, 249 mm SL.

Silurus soldatovi Nikolsky et Soin, 1948
(Fig. 30)

Silurus soldatovi Nikolsky and Soin, 1948: 1359; Berg, 1949: 474.
Silurus soldatovi soldatovi: Chen, 1977: 208.

No specimen was dissected, but one specimen was skinned in the head region to examine the dorsal view of the skull. Since the adult of this species grows over 1 m, all the specimens observed here were young or juvenile.

Dorsal fin rays 5–6; pectoral fin rays I, 11–14; pelvic fin rays i, 9–11; anal fin rays 78–87; caudal fin rays 7–8+7–8; vertebrae 17, 18+49, 51=67, 68 (2 specimens); branchiostegals 13–16; gill rakers 1–3+8–12.

Lower jaw prominently longer than upper; head 3.75±0.21 in standard length and extremely large; eye with free orbital rim; dorsal surface of body uniformly black and ventral surface white; one obscure white vertical line present along lateral line running along middle of body; two pairs of mandibular barbels; minute papillae clustered on tip of pair of maxillary barbels (Fig. 31); pectoral spine very weak and its anterior surface slightly granulated; vomerine teeth in broad non-separated patch with its posterior margin sharply notched.

Skull: Mesethmoid remarkably broad and its lateral process stout (Fig. 32); prominent sagittal crest rising in posterior part of skull.

Distribution. The Amur River, USSR and the Liao River, China.

Silurus torrentis sp. nov.
(Fig. 33)

Silurichthys leucopodus (not of Fowler, 1939): Wongrat, 1967: 85.

Specimens examined. Holotype—NSMT-P 50234. Adult female from Lampae stream, Khaoluk Village,

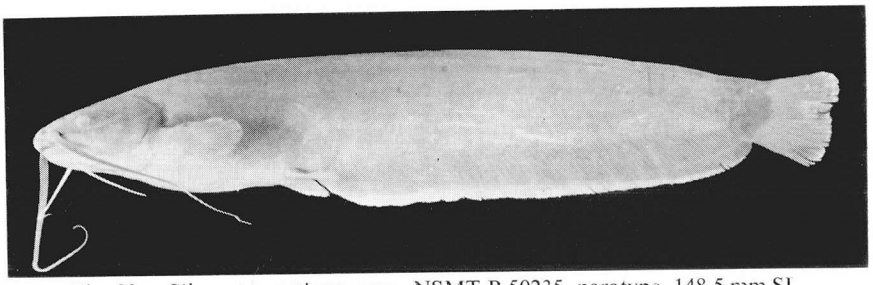

Fig. 33. *Silurus torrentis* sp. nov., NSMT-P 50235, paratype, 148.5 mm SL.

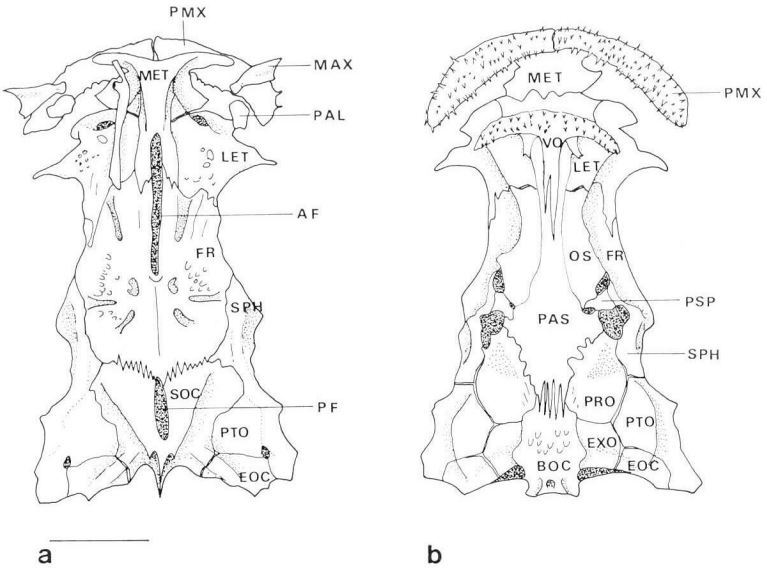

Fig. 34. Skull of *Silurus torrentis* sp. nov. a, dorsal view; b, ventral view. Abbreviations as in Fig. 5. Scale bar indicates 1 cm.

Trang, Thailand. Collected by a local fisherman on March 16, 1986. Paratypes—NSMT 50235–50239 (5 specimens). Data as for holotype. Specimens referred to—FBKU, uncatalogued, 2 specimens, same data as the type series; FBKU, uncatalogued, 2 specimens, collected in Klong Bang Son, Trang, Thailand (8°33′N, 98°55′E) by Jarjin Nabithabata on March 13, 1985; NIFI 00414, 3 specimens, Krating Waterfall, Chantaburi, Thailand; NIFI, uncatalogued, 2 specimens, locality unknown; NHRM 1934. 467. 5007, 3 specimens, collected in Mahlwedaung, Ye State, Burma, 18 Nov. 1934; NHRM 1934. 168. 3225, 7 specimens, collected in Patao, Kachin State, Burma, April 1934.

Diagnosis. Dorsal fin extremely small; colour in life dark olive dorsally and white ventrally; vomerine tooth band slender and nearly continous; corner of mouth just reaching or beyond anterior border of eye.

Description of holotype. Dorsal fin rays 3; pectoral fin rays I, 13; pelvic fin rays i, 7; anal fin rays 69; caudal fin rays 7+8; vertebrae 13+42=55; branchiostegals 12; gill rakers 1+4.

Head well depressed, 5.35 in SL; body compressed; eye covered with skin; snout short, 13.89 in SL; nostrils separated by 30.37 in SL; mouth inferior; a single pair of mandibular barbels, 8.45 in SL; maxillary barbel extending over pectoral fin, 2.96 in SL; anterior edge of pectoral spine smooth; posterior edge of pectoral spine serrated; dorsal origin 3.63 in SL; dorsal fin height 27.15 in SL; caudal fin almost truncated; gill rakers slender and small in number. Colour in life dark olive on dorsal and lateral surface, and white on ventral surface; rim of pectoral and anal fins white.

Standard length 179.2 mm; head length 33.5 mm; predorsal 49.3 mm; preanal 66.7 mm.

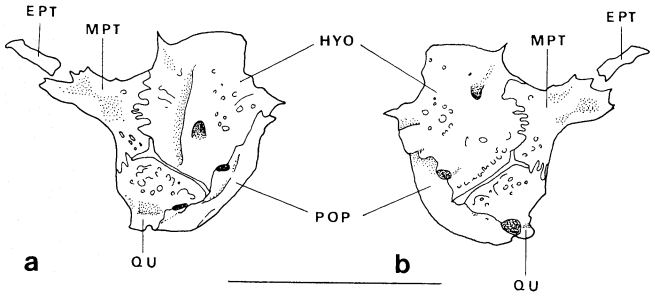

Fig. 35. Suspensorium of *Silurus torrentis* sp. nov. a, lateral view; b, medial view. Abbreviations as in Fig. 6. Scale bar indicates 1 cm.

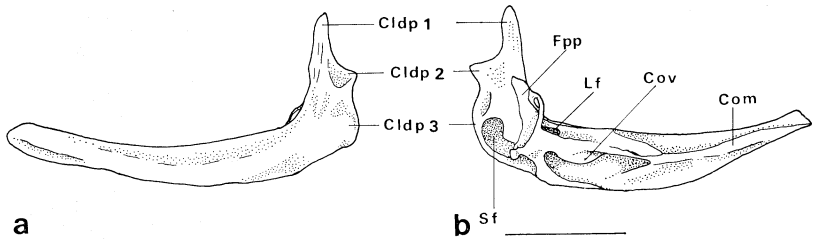

Fig. 36. Shoulder girdle of *Silurus torrentis* sp. nov. a, lateral view; b, medial view. Pectoral fin is removed. Abbreviations as in Fig. 7. Scale bar indicates 1 cm.

Paratypes. Dorsal fin rays 2–3 ($\bar{x}$=2.8; N=5); pectoral fin rays I, 12–13 ($\bar{x}$=I, 12.2; N=5); pelvic fin rays i, 6–8 ($\bar{x}$=i, 7.2; N=5); anal fin rays 63–70 ($\bar{x}$=66.6; N=5); vertebrae 12–13+41–44=54–56 ($\bar{x}$=55.2; N=5); branchiostegals 12–13 ($\bar{x}$=12.2; N=5); gill rakers 1+3 ($\bar{x}$=1+3; N=5).

Two specimens were dissected.

Skull (Fig. 34): Lateral process of lateral ethmoid prominent; antero-median margin of mesethmoid indented posteriorly with a gentle angle; base of lateral projection of mesethmoid strongly compressed; frontal extremely flat, sensory canals on it forming mere groove; sagittal crest broad and confined to posterior part of supraoccipital; posterior part of epioccipital and supraoccipital elevated to form a bump for origin of epaxial muscles; vomer having postero-lateral processes for attachment of a ligament connecting with entopterygoid.

Suspensorium (Fig. 35): Metapterygoid small compared with hyomandibular; entopterygoid an elongate and sheet-like bone; hyomandibular process well-developed and, in one specimen from Chantaburi, forming a pterygoid process to separate adductor mandibulae 3 and levator arcus palatini.

Shoulder girdle (Fig. 36): Vertical part of cleithrum short; ventral coracoid lamina poorly developed; bridge of coracoid strongly bending upward; coracoid connected with cleithrum by complex suture.

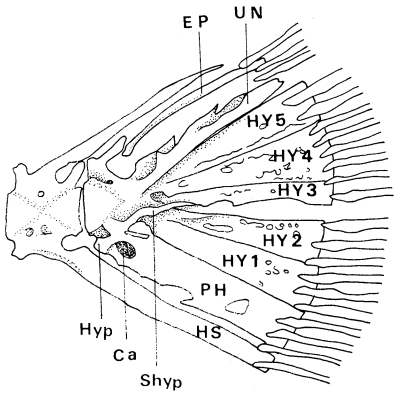

Fig. 37. Caudal skeleton of *Silurus torrentis* sp. nov. Abbreviations as in Fig. 8. Scale bar indicates 1 cm.

Caudal skeleton (Fig. 37): All hypural bones separated from each other; hypurapophysis fused with secondary hypurapophysis, both moderately developed; secondary hypurapophysis forming a well-developed shelf on hypurals 1 and 2.

Remarks. Theis species has been reported by Wongrat (1967) as *Silurichthys leucopodus* Fowler.

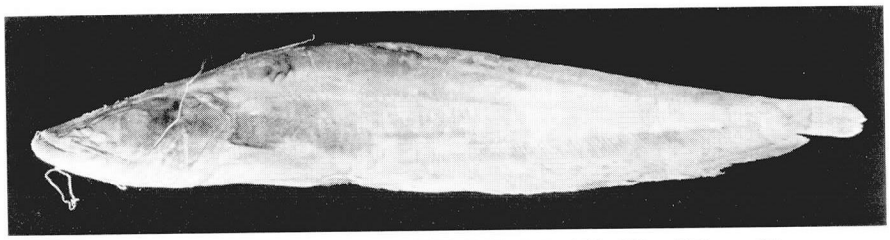

Fig. 38. *Silurus triostegus*, BMNH 1920. 3. 3: 168–176. 220 mm SL.

The meristic characters are nearly identical with the original description by Fowler (1939) (Table 1). However, the condition of the continuous anal and caudal fins is quite different. In the genus *Silurus*, the anal fin is continuous with the caudal fin and possesses a definite notch, whereas in the genus *Silurichthys* the two fins are completely united without any break and the posterior rays of the anal fin are longer than the anterior ones. Furthermore this species differs from *Silurichthys leucopodus* described by Fowler (1939) in the following characters: the form of the vomerine tooth patch, length of the maxillary barbels, and the colour of the pectoral fin and the border of the anal fin.

Based on these differences, this form was recognized as a species different from *Silurichthys leucopodus* Fowler.

Wongrat (1967) mentioned specimens only from Chantaburi, but the same forms were also collected in Trang and several places in Burma. A comparison of the meristics and body proportions of the specimens from these three different localities is given in Tables 2 and 3. Slight differences are evident among the specimens from Chantaburi, Trang and Burma, especially in the dorsal fin height, and the number of fin rays and gill rakers. In addition to these differences the colour of the specimens in life from Chantaburi is different from that from Trang. The whole body is black in the specimens from Chantaburi. The body proportions, however, do not differ significantly from each other, and therefore specimens from these three localities are regarded as a single species.

Etymology. The name *torrentis* (Latin) refers to the habitat of this species, torrents.

Distribution. Trang and Chantaburi, Thailand, and eastern Burma.

Silurus triostegus Heckel, 1841
(Fig. 38)

Silurus triostegus Heckel, 1841: 1090.

No specimen was dissected, but radiographs available.

Dorsal fin rays 4; pectoral fin rays I, 12–13; pelvic fin rays i, 9; anal fin rays 78–87; caudal fin rays 7–8+8; vertebrae 17+53=70; branchiostegals 14–15; gill rakers 2–3+10.

Lower jaw longer than upper; head 4.09±0.05 in standard length; two pairs of mandibular barbels in one specimen and only one in others; eye surrounded by free orbital rim; outer surface of pectoral spine smooth; dorsal surface of body mottled in pale yellowish brown and black, and black spots scattered on ventral surface in alcohol-preserved specimens; vomerine teeth in two patches forming a gentle curve separated by a small break. The mesethmoid is broad and not narrowed bilaterally at the base of the well-developed lateral process of this bone.

Distribution. Iraq.

Silurus wynaadensis Day, 1873

Silurus punctatus (not of Cantor, 1842): Day, 1868: 155.

Silurus wynaadensis Day, 1873: 237.

Dorsal fin rays 4; pectoral fin rays I, 10; anal fin rays 56; vertebrae 13+39=52.

Pelvic fin rays could not be counted. Upper jaw longer than lower; head 5.45 in standard length; body uniformly pale brown (specimen not well preserved); mandibular barbels two pairs and rather long, longer one nearly reaching base of pectoral fin; maxillary barbels extending over pectoral fin, but not reaching base of pelvic fin.

Distribution. India.

The meristics of the 17 species of the genus

Table 1. Comparison of *Silurichtys leucopodus* with *Silurus torrentis* sp. nov.

	Dorsal fin	Pectoral fin	Pelvic fin	Anal fin	Branchiostegals	Vomerine tooth patch
Silurichthys leucopodus (original description)	4	I, 10	i, 6	67	—	broad, continuous
Silurichthys leucopodus (from Wongrat, 1967)	4	I, 12–13	i, 8–9	62–68	12–14	—
Silurus torrentis sp. nov.	1–3	I, 10–13	i, 6–9	68–74	11–15	slender, continuous

Table 2. Comparison of the meristic characters of *Silurus torrentis* sp. nov. from three different localities.

Locality	N	Dorsal fin	Pectoral fin	Pelvic fin	Anal fin	Total vertebrae	Branchiostegals	Gill rakers
Chantaburi, Thailand	7	3	I, 10–12	i, 6–9	68–73	56–57	11–13	2–6
		($\bar{x}$=3)	($\bar{x}$=11.1)	($\bar{x}$=i, 6.1)	($\bar{x}$=71.4)	($\bar{x}$=56)	($\bar{x}$=12.1)	($\bar{x}$=4.4)
Trang, Thailand	10	2–3	I, 12–13	i, 6–8	63–74	54–56	12–13	4–5
		($\bar{x}$=2.7)	($\bar{x}$=12.2)	($\bar{x}$=i, 7.1)	($\bar{x}$=68.9)	($\bar{x}$=55.3)	($\bar{x}$=12.2)	($\bar{x}$=4.3)
Burma	10	1–2	I, 10–12	i, 7	68–74	55–57	12–15	2–5
		($\bar{x}$=1.8)	($\bar{x}$=10.4)	($\bar{x}$=i, 7)	($\bar{x}$=67.9)	($\bar{x}$=56)	($\bar{x}$=13.5)	($\bar{x}$=3.4)

Table 3. Comparison of the body proportions (in standard length) of *Silurus torrentis* sp. nov. from three different localities.

Locality	N	Head length	Dorsal height	Predorsal	Preanal	Snout	Caudal pednucle depth	Mandibular barbel	Maxillary barbel
Chantaburi, Thailand	7	5.40	26.3	3.64	2.78	13.3	11.4	3.0	8.5
		±0.161	±1.39	±0.087	±0.114	±1.10	±0.39	±1.10	±0.75
Trang, Thailand	10	5.32	25	3.57	2.64	13.6	13.3	2.7	8.3
		±0.252	±5.8	±0.161	±0.056	±1.07	±1.30	±0.42	±1.04
Burma	10	5.40	31	3.63	2.60	14.2	13.1	3.2	8.8
		±0.133	±4.8	±0.069	±0.114	±1.27	±0.93	±0.37	±1.46

Silurus are shown in Table 4.

Notes on *Silurus goae*

In addition to the 17 valid species mentioned above, *Silurus goae* Haig, 1950 (two specimens including holotype) was examined. The meristics of this species were as follows: dorsal fin rays 4; pectoral fin rays I, 11, 12; pelvic fin rays 8; anal fin rays 67, 72; vertebrae 10+44=54; branchiostegals 13; gill rakers 3+5. *S. goae* externally resembles some members of *Silurus*, but has several unique features in osteology and other morphological characters. These include a smaller number of abdominal vertebrae, a remarkably developed sagittal crest on the supraoccipital, a black spot behind the gill opening, and a forked caudal fin with rounded tips. All of these characters are in good agreement with diagnostic characters of the genus *Ompok*, and I therefore conclude that *S. goae* does not belong to *Silurus* but to *Ompok*.

Key to species of *Silurus*

1a Lower jaw prominent.....2
1b Upper jaw prominent.....13
2a Anterior surface of pectoral spine smooth 3
2b Anterior surface of pectoral spine unsmooth 4
3a Vomerine teeth in a continuous band ..... *S. glanis*
3b Vomerine teeth in two patches..*S. triostegus*
4a Anterior surface of pectoral spine with granules 5
4b Anterior surface of pectoral spine serrated 10
5a Anterior surface of pectoral spine with a row of granules 6
5b Anterior surface of pectoral spine with scattered granules 8
6a Total vertebrae less than 60; maxillary barbel not extending over base of pectoral fin .... *S. mento*
6b Total vertebrae 61 and more; maxillary barbel extending base of pectoral fin....7
7a Total vertebrae less than 63; maxillary barbel reaching anterior one-third of pectoral fin ..... *S. grahami*
7b Total vertebrae more than 67; maxillary extending to half the pectoral fin..... .....*S. lanzhouensis*
8a Standard length less than 4 times head length; numerous papillae at tip of maxillary barbel .....*S. soldatovi*
8b Standard length more than 4 times head length; papillae absent on maxillary barbel 9
9a Maxillary barbel extends over base of pectoral fin; gape very wide, extending over middle of eye.....*S. meridionalis*
9b Maxillary barbel not reaching base of pectoral fin; gape not reaching middle of eye ..... *S. biwaensis*
10a Total vertebrae less than 70.....11
10b Total vertebrae more than 70..*S. aristotelis*
11a Anterior surface of pectoral spine strongly serrated; standard length less than 5 times head length; caudal fin separated into two lobes 12
11b Serration of pectoral spine weak; standard length more than 5 times head length; caudal fin not separated into two lobes..... ..... *S. microdorsalis*
12a Dorsal view of snout slightly pointed; vomerine teeth in two patches...*S. lithophilus*
12b Dorsal view of snout rounded; vomerine teeth usually in a continuous band..... ..... *S. asotus*
13a Adults with four mandibular barbels; vomerine tooth patch continuous 14
13b Adults with two mandibular barbels....15
14a Vomerine tooth patch continuous; border of anal fin white.....*S. gilberti*
14b Vomerine teeth in two separate patches ..... *S. wynaadensis*
15a Vomerine teeth in a continuous band....16
15b Vomerine teeth in two patches; body surface smooth..... *S. cochinchinensis*
16a Body surface smooth; dorsal fin rudimentary; body dorsally black, ventrally white .....*S. torrentis* sp. nov.
16b Body surface rough with sensory tubercles; body entirely dark brown.....*S. afghana*

Taxonomic invalidity of *Parasilurus*

The genus *Silurus* discussed here was formerly divided into two genera, *Silurus* Linnaeus, represented by *S. glanis*, and *Parasilurus* Bleeker, represented by *P. asotus*. The only diagnostic char-

Table 4. Meristic characters of 18 species of the genus *Silurus* and *Hito taytayensis*. * Radiographs included; ** after Sauvage (1882). ——: no data. D., dorsal fin rays; P., pectoral fin rays; Pel., pelvic fin rays; A., anal fin rays; GR., gill rakers; B., branchiostegals; SL, standard length; HL, head length.

Species	N	D.	P.	Pel.	A.	GR.	B.	Vertebrae	Manibular barbel	SL/HL	Anterior surface of pectoral spine
S. glanis	5*	3–4	I, 15	12–13	83–87	12	15–16	18—19+54—56=72—74	4	4.65	smooth
S. triostegus	3	4	I, 12–13	10	78–87	12–13	14–15	17+53=70	2	4.09	smooth
S. lanzhouensis	10*	4–5	I, 11–13	9–11	70–88	9–11	13–15	16+52—53=68—69	2	4.55	granulated
S. mento	19	3–4	I, 9–11	8–10	61–73	12–15	12–15	12—15+41—46=54—60	2	4.01	granulated
S. grahami	8	4–5	I, 10–12	9–11	67–75	10–13	13–15	14—15+46—49=61—63	2	4.35	granulated
S. soldatovi	12	5–6	I, 11–14	10–12	78–87	10–14	13–16	17—18+49—51=67—68	4	3.79	granulated
S. meridionalis	17	5–6	I, 13–16	10–12	71–85	12–17	12–17	15—18+47—50=64—68	2	4.15	granulated
S. biwaensis	16	4–6	I, 13–15	10–13	71–83	11–15	14–16	13—17+49—52=63—68	2	4.29	granulated
S. asotus	18	4–6	I, 10–13	9–12	59–88	9–12	12–16	12—14+46—50=59—64	2	4.64	serrated
S. lithophilus	9	4–5	I, 10–12	10–12	77–82	9–11	14–17	12—15+48—55=62—69	2	4.62	serrated
S. aristotelis	2	2, 3	I, 11	9	75	14, 15	13	15+45, 46=60, 61	2	4.10	serrated
S. cochinchinensis	12*	4	I, 8–10	8–9	58–66	4–5	10–13	11—13+41—45=53—57	2	5.25	smooth
S. gilberti	7	4	I, 10–11	8–9	57–66	4–7	10–12	11—13+39—42=50—55	4	5.25	smooth
S. microdorsalis	14	1–3	I, 9–11	9–11	61–74	6–8	12–13	13—14+45—47=59—60	2	5.58	serrated
S. wynaadensis	1	4	I, 10	—	56	—	—	13+39=52	4	5.45	smooth
S. afghana	1	2	I, 11	9	74	—	—	15+45=60	2	5.26	smooth
S. torrentis sp. nov.	27	1–3	I, 10–13	7–9	63–74	2–6	11–15	12—13+41—45=55—57	2	5.42	smooth
*S. chantrei***		3	I, 13	10	65	—	—	—	—	—	smooth
Hito taytayensis	20	4	I, 10–11	6–8	59–68	9–13	10–11	9—10+38—41=48—51	4	4.92	smooth

acter separating these two genera was the number of mandibular barbels: *Silurus* having two pairs, while *Parasilurus* had only one pair (Bleeker, 1862; Smith, 1945; Berg, 1949); Nikolsky, (1961). However, Haig (1950) and Chen (1977) reported that the adults of *P. cochinchinensis* and *S. gilberti* were variable in the number of mandibular barbels; individuals with a single pair and two pairs of barbels were found within a species. This variation was confirmed in the present study and also documented for the first time in another species, *S. triostegus*. It has been reported that in juvenile *P. asotus*, one of the two pairs of mandibular barbels disappears in the course of ontogeny (Atoda, 1935). My own observations of the growth and development of the Japanese *Silurus* species (Kobayakawa, unpublished) have confirmed this change in *S. asotus*, and similar ontogenetic changes in barbels were also observed in two other Japanese species, *S. biwaensis* and *S. lithophilus*. Examination of a series of preserved specimens revealed that *S. mento* and *S. meridionalis* also have two pairs of mandibular barbels in their juvenile stage, but similarly change the number of mandibular barbels during their ontogeny.

Thus the number of mandibular barbels is proved to be an unreliable generic diagnosis, as already indicated by Haig (1950) and Chen (1977).

The results of observations of other morphological characters are also not in favour of recognizing *Parasilurus*. *P. asotus*, the type species of the genus *Parasilurus*, is more similar to the type species of *Silurus*, *S. glanis*, than to "*Parasilurus*" *cochinchinensis* in various characteristics, such as the shape of the skull and hyomandibular, the sagittal crest on the skull, the entopterygoid, the pectoral spine, and the cleithrum. Since no biologically significant difference is recognized at present, the genus *Parasilurus* is regarded as invalid and relegated to a synonym of *Silurus*.

Taxonomic status of several forms

Examination of the radiograph of the holotype revealed several diagnostic characters of *S. bedfordi* Regan (1908), such as the serration of the anterior surface of the pectoral spine, numbers of vertebrae, anal fin rays, and morphometrics, to fall well within the variation range of *S. asotus*. Accordingly, *S. bedfordi* is synonymized with *S. asotus* in the above revision.

Chen (1977) described *S. meridionalis* as a subspecies of *S. soldatovi*, but the difference in the skull shape between these two forms is so great that they are believed to represent two distinct species. Chen also recognized *S. grahami* as a subspecies of *S. mento*, but the two forms greatly differ in the proportion of the body, colour pattern, and the shape of the mesethmoid, and are therefore considered here as different species.

Haig (1950) considered *S. wynaadensis* and *S. afghana* to be synonyms of *S. cochinchinensis*, but from my observations of type specimens of these species they are judged to be clearly independent species as revealed by the difference in their body colour, body proportion, and number of vertebrae.

Phylogenetic relationships

Monophyly and outgroup of the genus *Silurus*. Based on only three morphological characters, Chen (1977) divided Chinese species of *Silurus* into three groups, represented by *S. cochinchinensis*, *S. asotus*, and *S. soldatovi*, respectively. However, he failed to consider species distributed outside China, and the relationships of species in the genus *Silurus*, as a whole, have not been studied. In recognizing the 17 valid species in the genus *Silurus*, I studied almost all of the hitherto-named taxa from the whole genus range. I utilized cladistic methodology to analyze the phylogeny among 12 species of *Silurus* for which adequate data were available on the basis of a larger number of characters. The genus *Silurus* is one of the nine genera belonging to the family Siluridae and is characterized by the following autapomorphies: 1) anal and caudal fins confluent with a distinct notch between, i.e. the last anal fin ray is shorter than the penultimate ray; 2) dorsal fin small; 3) caudal fin either rounded, truncated or emarginated medially. On the basis of these characters it is argued that the genus *Silurus* is monophyletic.

In order to determine the sister group of the genus *Silurus*, 20 morphological characters of nine nominal genera of the family Siluridae (*Belodontichthys*, *Ceratoglanis*, *Hemisilurus*, *Hito*, *Kryptopterus*, *Ompok*, *Silurichthys*, *Silurus*, and *Wallago*) were analyzed (Kobayakawa, unpublished). In this study, Bagridae, Ictaluridae, and Plotosidae were considered the outgroups of

Siluridae (Howes, 1983). As the result, the genus *Hito* was found to be the sister group of *Silurus*.

Character analysis. Out of the 38 morphological characters examined, the 18 characters discussed below were chosen as suitable for phylogenetic analysis. The character polarity was determined on the basis of outgroup comparison and ontogenetical data were not considered; the ontogeny of several species will be discussed later.

Character 1. Condition of anterior surface of pectoral spine. Four states of this character are observed in the genus *Silurus*; smooth, granulated in a single row, granulated, and serrated. On the basis of the condition in the outgroup, a smooth surface is determined as plesiomorphic, and a granular or serrated surface as apomorphic.

State 0: smooth. State 1: granulated in a single row. State 2: granulated. State 3: serrated.

Direction of change. 0→1→2, 0→3

Character 2. Ratio of standard length to head length. The outgroup has the value intermediate between the extremes seen in the species of *Silurus*. It is difficult to determine the polarity for the morphometric data, because the values vary from species to species, and usually it is subjective to cut a continuous value at a certain point. The relative head length, however, has a correlation with character 1; species with a large ratio have a smooth pectoral spine, and this condition is considered to be plesiomorphic. The outgroup has low value (ratio 4.92).

State 0: ratio 3.7–5.0. State 1: ratio 5.0–6.0.

Direction of change. 0→1

Character 3. Shape of testis. The testis of the outgroup is not split into slender ribbons but only fringed; a fringed testis is considered plesiomorphic and split testis apomorphic.

State 0: fringed. State 1: split.

Direction of change. 0→1

Character 4. Number of vertebrae. As in morphometric data, it is difficult to determine a morphocline for the number of vertebrae. The total number of vertebrae in the outgroup vaies from 48 to 51. These values are relatively low among the family Siluridae. A lower number of vertebrae is inferred plesiomorphic.

Character 5. Secondary hypurapophysis. Lundberg and Baskin (1969) studied the caudal skeleton of Siluriformes, but were unable to reach a firm conclusion regarding polarity. They assumed that species with an eel-like locomotion possessed a weak and undeveloped hypurapophysis. The secondary hypurapophysis of the outgroup forms a shelf on hypurals 1 and 2, and is not fused with the hypurapophysis. It is inferred that the presence of a shelf on hypurals 1 and 2 is plesiomorphic, whereas a shelf on hypural 1 is apomorphic.

State 0: shelf on hypurals 1 and 2. State 1: shelf on hypural 1.

Direction of change. 0→1

Character 6. Fusion of hypurapophysis and secondary hypurapophysis. The hypurapophysis of the outgroup is not fused with secondary hypurapophysis. An unfused condition of hypurapophysis and secondary hypurapophysis is hypothesized to be plesiomorphic and a fused condition apomorphic.

State 0: hypurapophysis not fused with secondary hypurapophysis.

State 1: hypurapophysis fused with secondary hypurapophysis.

Direction of change. 0→1

Character 7. Gill rakers. The members of the genus *Silurus* are roughly divided into two groups by the number of gill rakers. This character is correlated to the ratio of the relative head length. The outgroup has 9–13 gill rakers, and these values are intermediate between those of the two groups observed in the genus *Silurus*. Although it is difficult to determine polarity, 9 or more gill rakers are considered to be apomorphic.

State 0: less than 9 gill rakers. State 1: 9 or more gill rakers.

Direction of change. 0→1

Character 8. Mouth. The mouth of the outgroup is inferior, and this condition is con sidered to be plesiomorphic.

State 0: inferior. State 1: superior.

Direction of change. 0→1

Character 9. Caudal fin. Since the outgroup has a forked caudal fin, the forked condition is inferred as plesiomorphic, and unforked apomorphic.

State 0: forked and emarginated medially. State 1: truncated.

Direction of change. 0→1

Character 10. Width of mesethomid. The mesethmoid of the outgroup is constricted at the base of the lateral projection of this bone, and this condition is inferred as plesiomorphic.

State 0: constricted at the base of lateral pro-

jection. State 1: unconstricted.

Direction of change. 0→1

Character 11. Sagittal crest. The sagittal crest of the outgroup is restricted to the posterior part of the supraoccipital, and only a broad bump is formed. On the basis of outgroup comparison, a broad sagittal crest restricted to the posterior part of the supraoccipital is assumed to be plesiomorphic, and a well-developed sagittal crest apomorphic.

State 0: broad and restricted to the posterior part of the supraoccipital. State 1: well-developed.

Direction of change. 0→1

Character 12. Cleithrum. The length of the vertical part of the cleithrum seems to be related with the depth of the skull (Table 5), i.e. a deep skull with a well-developed sagittal crest retains a long vertical portion of the cleithrum. The outgroup has the cleithrum with a short vertical part, and this is considered to be plesiomorphic.

State 0: with short vertical portion. State 1: with long vertical portion.

Direction of change. 0→1

Character 13. Number of mandibular barbels. The outgroup has one pair of mandibular barbels, which is considered to be plesiomorphic. In some species, the juvenile has two pairs of mandibular barbels, and retains this condition. In others, only one pair is present.

State 0: one pair. State 1: two pairs.

Direction of change. 0→1

Character 14. Entopterygoid. The entopterygoid of the outgroup is a sheet bone. On the basis of outgroup comparison, a sheet-like entopterygoid is considered as plesiomorphic, and a rod-like one apomorphic.

State 0: sheet-like. State 1: rod-like.

Direction of change. 0→1

Character 15. Hyomandibular. The hyomandibular of the outgroup is elongated dorsoventrally, and this state is regarded as more plesiomorphic than that of the antero-posteriorly elongated state.

State 0: dorso-ventrally elongated. State 1: antero-posteriorly elongted.

Direction of change. 0→1

Character 16. Suture between cleithrum and ventral part of coracoid. The cleithrum and ventral part of the coracoid in the outgroup are connected by a suture. On the basis of the outgroup analysis, connection by suture is considered to be plesiomorphic.

State 0: sutured. State 1: non-sutured.

Direction of change. 0→1

Table 5. Character state distribution of the genus *Silurus* and the outgroup, *Hito taytayensis*. As for the character numbers and state numbers, see the text. /: polarity could not be determined. ?: not examined.

Species	Character																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Silurus afghana	0	1	?	/	?	0	?	0	1	0	?	?	1	?	?	?	0	0
S. aristotelis	3	0	0	/	0	0	1	1	0	1	1	1	0	1	1	1	1	0
S. asotus	3	0	0	/	0	0	1	1	0	1	1	1	0	1	1	1	1	1
S. biwaensis	2	0	0	/	1	0	1	1	0	1	1	1	0	1	1	1	1	0
S. cochinchinensis	0	1	1	/	1	0	0	0	1	0	0	0	0	0	0	1	0	0
S. gilberti	0	1	1	/	1	1	0	0	1	0	0	0	1	0	0	1	0	0
S. glanis	0	0	?	/	0	0	1	1	0	1	1	1	1	1	1	1	1	0
S. grahami	1	0	0	/	0	0	1	1	0	1	1	1	0	1	1	1	1	0
S. lanzhouensis	1	0	?	/	?	?	1	1	0	1	1	?	0	?	?	?	1	0
S. lithophilus	3	0	0	/	0	0	1	1	0	1	1	1	0	1	1	1	1	1
S. mento	1	0	?	/	0	0	1	1	0	1	1	1	0	1	1	1	1	1
S. meridionalis	2	0	?	/	0	0	1	1	0	1	1	1	0	1	1	1	1	0
S. microdorsalis	3	1	1	/	0	0	0	1	1	0	0	0	0	0	0	1	0	0
S. soldatovi	2	0	?	/	?	?	1	1	0	1	1	?	1	?	?	?	1	0
S. torrentis	0	1	1	/	1	1	0	0	1	0	0	0	0	0	0	0	0	0
S. triostegus	0	0	?	/	?	?	1	1	0	1	?	?	0	?	?	?	1	0
S. wynaadensis	0	1	?	/	?	?	?	0	1	0	?	?	0	?	?	?	0	0
Hito taytayensis	0	0	0	/	0	0	0	0	0	0	0	0	0	0	0	0	0	0

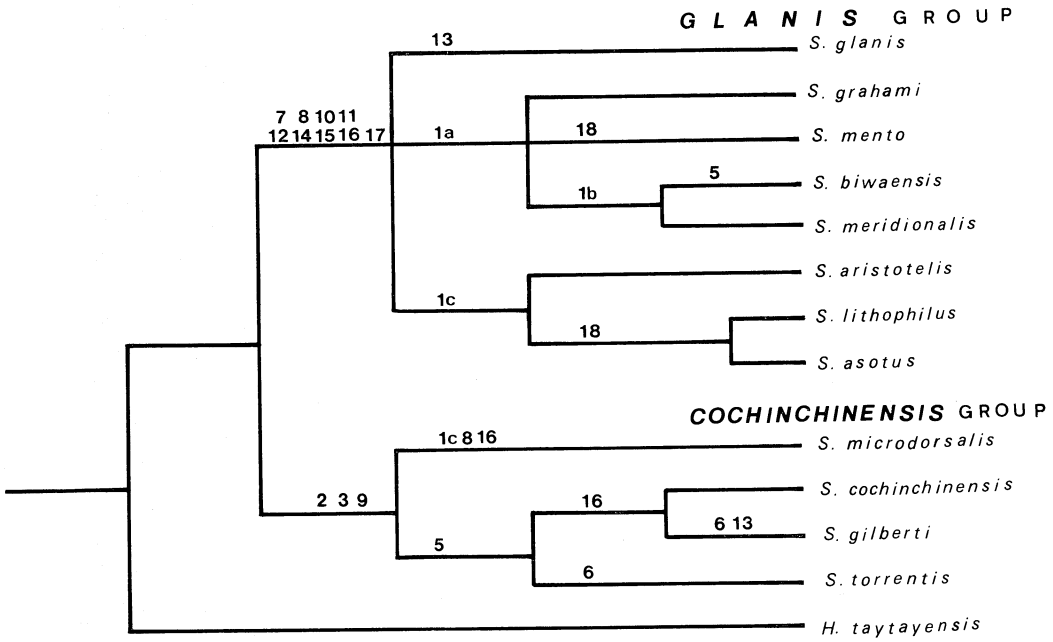

Fig. 39. Phylogenetic relationships of 12 species available for anatomical study of the genus *Silurus*. Numbers on each branch indicate character numbers of synapomorphy. 1 a–c, character state 1–3 of character 1, respectively.

Character 17. Margin of eye. In some species, the eye is covered with skin, while in others, the eye has a free orbital rim. The outgroup shows the former condition, and the eye covered with skin is considered to be plesiomorphic.

State 0: covered with skin. State 1: with free orbital rim.

Direction of change. 0→1

Character 18. Lateral line. The lateral line of the outgroup runs only vertically. Some species of *Silurus* have a horizontal lateral line in addition to the usual vertical one. On the basis of outgroup analysis, the condition with horizontal lateral line only is regarded as plesiomorphic.

State 0: only vertical. State 1: both vertical and horizontal.

Direction of change. 0→1

The character state distribution of these 18 characters is shown in Table 5.

Inferred phylogeny. The phyletic relationships among the 12 species thus inferred are shown in Fig. 39, from which this genus is revealed to be split into two major species groups. Chen (1977) recognized three species groups in the Chinese *Silurus*, as noted above. Unfortunately, I could not dissect any specimens of *S. soldatovi*, and the species is therefore not included in the above phylogenetic analysis. From my observation, however, the differences between *S. asotus* and *S. soldatovi* is minor compared with the differences found between either of these two species and *S. cochinchinensis*. Accordingly, it would be safe to conclude that this genus should be divided into two, and not three, major species groups. Here these groups are named the *glanis* group and the *cochinchinensis* group. A comparison of the main differences between these two groups is given in Table 6.

The *glanis* group is composed by *S. asotus*, *S. aristotelis*, *S. biwaensis*, *S. glanis*, *S. grahami*, *S. mento*, *S. meridionalis*, and *S. lithophilus*. From the main characteristics listed in Table 4, *S. lanzhouensis*, *S. soldatovi*, and *S. triostegus* are also regarded as members of this group. The *cochinchinensis* group consists of *S. cochinchinensis*, *S. gilberti*, *S. microdorsalis*, and *S. torrentis*. *S. afghana* and *S. wynaadensis* are also included in this group on the basis of the characteristics given in Table 6. Although *S. chantrei* Sauvage was not treated in the present work, the species may be a member of the *cochinchinensis* group, since the description of this species (Sauvage, 1882)

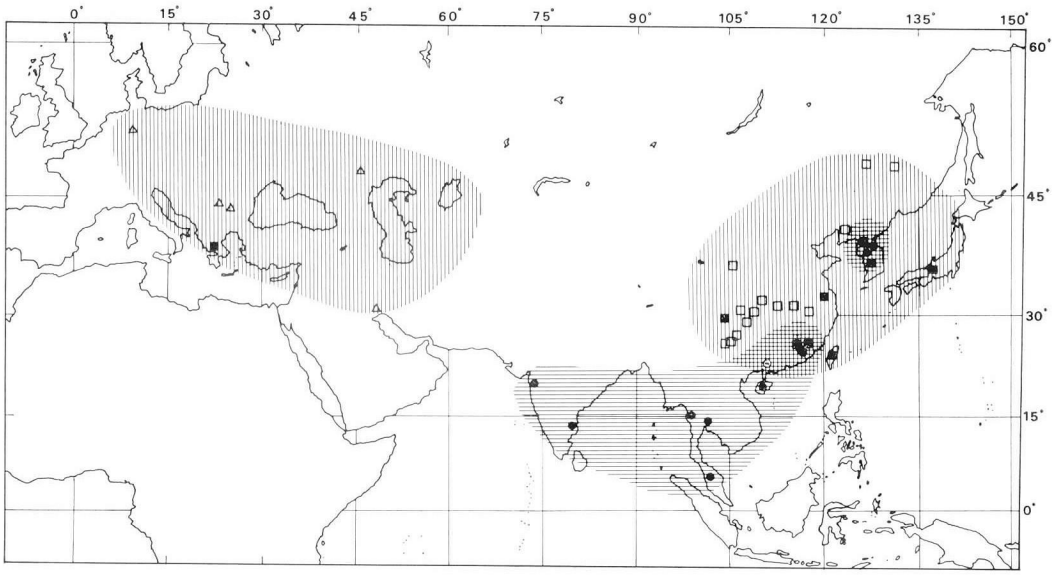

Fig. 40. Distribution of the genus *Silurus*. Horizontally hatched area indicates the distribution range of *cochinchinensis* group, vertically hatched area that of the *glanis* group. Localities of specimens examined are shown: solid circle, species of *cohcinchinensis* group; triangle, species with smooth anterior surface of pectoral spine in *glanis* group; square, species with granulated anterior surface of pectoral spine in *glanis* group; solid square, with serrated anterior surface of pectoral spine in *glanis* group.

indicates its close resemblance to *S. afghana*.

From the phylogenetic tree shown in Fig. 39, it is possible to further subdivide each major group. Regarding the *cochinchinensis* group, *S. microdorsalis* is separable from the other species, but available information is inadequate to recognize clear subgroups. Similarly the *glanis* group seems to be separated into at least three groups (Fig. 39). When the species not shown in the tree (*S. lanzhouensis*, *S. soldatovi*, and *S. triostegus*) are added to this group, a single character (character 1; anterior surface of the pectoral spine) may be used to further divide the *glanis* group into three subgroups. The first subgroup is composed of *S. glanis* and *S. triostegus*, whose anterior surface of the pectoral spine is completely smooth, the second consists of *S. lanzhouensis*, *S. mento*, *S. grahami*, *S. meridionalis*, *S. biwaensis*, and *S. soldatovi*, whose anterior surface of the pectoral spine is granulated, and the third consists of *S. asotus*, *S. lithophilus*, and *S. aristotelis*, whose anterior surface of the spine is well-serrated. In order to confirm the validity of these subgroups, further morphological and anatomical information is required.

Pattern of distribution

Due to the limited amount of available information, it is impossible to accurately determine the exact distribution range of each species at present. However, the locality records attached to the observed specimens give an outline of the range of the two major species groups in the genus *Silurus*. The range of *Silurus*, as a whole, is clearly separated in Europe and Asia (Fig. 40). In Europe, only members of the *glanis* group occur. In contrast, the two species groups occur in Asia, where their ranges are roughly split into two regions. This distribution pattern seems to support the validity of the two major species groups recognized from the phylogenetic analysis based on the external morphology and anatomy.

The outgroup species, *Hito taytayensis*, is endemic to the northern part of Palawan and Caramians, the Philippines. On the basis of this distribution range of *Hito* and its phylogenetic relationships to the two species groups of *Silurus*, it is inferred that the genera *Hito* and *Silurus* have differentiated in Southeast Asia, from where *Silurus* later extended its distribution range.

Table 6. Comparison of the two species groups of the genus *Silurus*.

Character	*cochinchinesis* group	*glanis* group
Mouth	inferior	superior
Standard length/head length	>5	<5
Total vertebrae	<60	>60
Gill rakers	less than 9 and reduced	9 and more and well developed
Anterior surface of pectoral spine	smooth or slightly serrated	smooth, serrated, or granulated
Entopterygoid	sheet bone	rod-like bone
Hyomandibula	vertically elongated	transversally elongated
Testis	split into slender ribbons	fringed

The pattern of distribution and the estimated phylogenetic relationships of the two species groups seem to support this idea. The distribution range of the *cochinchinensis* group is mainly in southeastern Asia and the southern part of eastern Asia, with the exception of *S. microdorsalis* which extends north to Korea. This species is particularly interesting. The distribution of *S. microdorsalis* is slightly separate from other members of the *cochinchinensis* group, and this species is morphologically more similar to the *glanis* group than are other members of the *cochinchinensis* group, as shown in the phylogenetic tree. It is possible that this species might represent a relict, retaining some character states similar to those of the ancestral form of the *glanis* group.

The geographic distribution of the *glanis* group is clearly split into two wide ranges, one in central Europe and the other in East Asia, being separated by the Mongolian Plateau (Lindberg, 1972). *S. aristotelis*, a member of one of the subgroups of the *glanis* group, is isolated in the Balkan Peninsula far from the other two members of the same subgroup, *S. asotus* and *S. lithophilus*, which are distributed in eastern Asia. The Himalayan orogeny might have a serious effect on splitting the distribution range of the *glanis* group. Since the fossil record of this genus is very poorly known (Obrchev, 1964; Kobayakawa and Okuyama, 1984), it is difficult to infer from which of the present centers the ancestral form of the *glanis* group arose.

The distribution ranges of the two major groups overlap at the eastern edge of Asia. Available data indicate that the members of the *cochinchinensis* group inhabit upper streams or more rapid running waters than the members of the *glanis* group (Day, 1878; Uchida, 1939; Joen, personal communication), and therefore it is probable that ecological isolation exists between the members of these two major groups.

Ontogeny and phylogeny

Since the ontogeny of only several members of the *glanis* group has been studied, it is difficult to generalize the relationship between ontogeny and phylogeny in the genus *Silurus*. Regarding the ontogeny of the three Japanese species of the *glanis* group, however, detailed information is available (Kobayakawa, unpublished). From that study, the juveniles, in comparison with adults, have unique conditions in several characters: the anterior surface of the pectoral spine is smooth, the skull is flat both dorsally and ventrally, the cleithrum is gently curved, and the mouth is inferior. When these juvenile features are considered, the conditions of the corresponding chraracters found in the *cochinchinensis* group are regarded as juvenilized ones of the *glanis* group. These ontogenetical considerations again seem to confirm the validity of grouping them into two major species groups, and suggest that the ontogeny has strongly affected the phylogeny in the evolution of the genus *Silurus*. The two major species groups, the *cochinchinensis* group and the *glanis* group, mentioned above seem to deserve generic status, but in this report, I will reserve further discussion until all genera of Siluridae have been studied in detail.

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タイおよびビルマ産の1新種を含むナマズ属魚類の分類学的再検討

小早川みどり

ナマズ科魚類はユーラシア大陸に広く分布するが，これまでに知られている9属のうち，ナマズ属 *Silurus*は，特に分布が広い．本属については分布が広いため標本の入手が容易でないこともあり，系統分類学的な研究はまだなされておらず，属の再検討を行った Haig (1950) と中国産の種の再検討を行った Chen (1977) の研究があるにすぎない．したがって本属にはこれまでに何種が記載されているかも明確ではなかった．また，本属は下顎の鬚の数によって *Silurus* 属と *Parasilurus* 属に分けられていたが，Haig (1950) および Chen (1977) はいくつかの種で下顎の鬚の数には種内変異が認められ，属の特徴とするに値しないことを指摘している．本研究では，1新種を含む17種を有効な種と認め，*S. bedfordi* Regan は *S. asotus* Linnaeus の同物異名とし，*S. goae* Haig は *Ompok* 属とした．また，新種 *S. torrentis* を記載した．これら17種の外部形態を，12種については解剖学的にも比較し，分岐分類法によって系統関係を推定した．その結果，本属を *Silurus* と *Parasilurus* に分けるのは妥当ではなく，*Parasilurus* は前者の同物異名であると認めた．さらにいくつかの形態的特徴により，本属は大きく2つの種群に分けられることがわかり，*cochinchinensis* 種群，*glanis* 種群と名づけた．*cochinchinensis* 種群は *glanis* 種群の稚魚的な特徴を維持していた．これら2つの種群は，例外はあるものの，分布からもその有効性が確かめられた．これら2つの種群は属に相当するとも考えられるが，今後ナマズ科の他の属との比較を行った上で検討すべきであろう．

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